FACTORS AFFECTING THE ADOPTION OF INNOVATION AND ITS ECONOMIC IMPLICATIONS IN THE BEEF CATTLE INDUSTRY IN PENINSULAR MALAYSIA

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FARAH ADILA ABDULLAH

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Tajuk Tesis / Disertasi *(Title of the Thesis / Dissertation)*	:	**Factors Affecting the Adoption of Innovation and its Economic Implications in the Beef Cattle Industry in Peninsular Malaysia**
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Nama Penyelia/Penyelia-penyelia *(Name of Supervisor/Supervisors)*	:	**Dr. Mohd Saifoul Zamzuri Noor**
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ABSTRACT

Beef cattle farming in Malaysia is an essential activity in the agricultural industry. The demand for beef in Malaysia is higher than the supply, so the local producers need to increase productivity to fulfil the population's needs. The low self-sufficiency and high import dependency ratios have become the primary concern as they have had the same pattern for many years. Besides, the uncertain climate such as flood and drought have also affected cattle productivity as well as a spike in ruminant feed prices. The limited grassing area and high reliance on forages have also become the main constraints in beef cattle farming. Hence, to overcome these challenges, strategies in adopting innovation by local cattle producers are crucial. This study aims to determine factors affecting innovation adoption among beef cattle farmers in Peninsular Malaysia and its economic implications in beef cattle industry. Face-to-face interview using structured questionnaires involving 233 beef cattle farmers in Kedah, Selangor, Kelantan and Johor was conducted. The major finding indicated that herd size, farmer-to-farmer extension and access to information significantly influenced the adoption of innovation. Moreover, the adoption of innovation and the ownership of many assets can further improve farm performance. To earn high profits in business, beef cattle farmers need to accept the innovations introduced and be able to control their assets well. For policy implications, the implementation of extension programs must be suited to the needs of the farmers, besides regular meetings among farmers and extension agents. The information access on innovation and the market linkage is also crucial for the players.

Keywords: beef cattle farming, extension programs, import dependency ratio, innovation adoption, self-sufficiency ratio.

ABSTRAK

Penternakan lembu pedaging di Malaysia merupakan aktiviti penting dalam industri pertanian. Permintaan daging lembu di Malaysia adalah lebih tinggi daripada penawaran, maka pengeluar tempatan perlu meningkatkan produktiviti bagi memenuhi keperluan penduduk. Kadar sara diri yang rendah dan nisbah pergantungan import yang tinggi telah menjadi kebimbangan utama kerana ia masih mempunyai corak yang sama selama bertahun-tahun. Selain itu, iklim yang tidak menentu seperti banjir dan kemarau turut menjejaskan produktiviti lembu serta kenaikan harga makanan ruminan. Kawasan ragut yang terhad dan pergantungan yang tinggi terhadap rumput foraj juga menjadi kekangan utama. Oleh itu, strategi menerimaguna inovasi di kalangan penternak lembu adalah penting untuk mengatasi masalah ini. Kajian ini adalah bertujuan untuk menentukan faktor yang mempengaruhi penerimagunaan inovasi dalam kalangan penternak lembu pedaging di Semenanjung Malaysia dan implikasi ekonomi dalam industri ini. Satu temu bual secara bersemuka menggunakan soal selidik berstruktur melibatkan 233 penternak lembu pedaging di Kedah, Selangor, Kelantan dan Johor telah dikendalikan. Dapatan utama menunjukkan bahawa bilangan ternakan, perkhidmatan pengembangan antara petani ke petani dan akses kepada maklumat adalah signifikan dan mempengaruhi penerimagunaan inovasi. Selain itu, penerimagunaan inovasi dan pemilikan jumlah asset yang banyak dapat meningkatkan lagi prestasi ladang. Untuk memperoleh keuntungan yang tinggi dalam perniagaan, penternak lembu pedaging perlu menerima inovasi yang diperkenalkan dan mampu mengawal aset mereka dengan baik. Bagi implikasi dasar, pelaksanaan program pengembangan mestilah bersesuaian dengan keperluan petani, selain perjumpaan berkala antara penternak dan ejen pengembangan. Selain itu, akses maklumat mengenai inovasi dan rangkaian pasaran juga adalah penting kepada penternak lembu pedaging.

Kata kunci: kadar sara diri, nisbah pergantungan import, penerimagunaan inovasi, penternakan lembu pedaging, program pengembangan.

DECLARATION

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; and any editorial work, paid or unpaid, carried out by a third party is acknowledged.

LIST OF PUBLICATIONS

Abdullah, F. A., Ali, J., & Noor, M. S. Z. (2020). The adoption of innovation in ruminant farming for food security in Malaysia: A narrative literature review. *Journal of Critical Reviews*, *7*(6), 738–743. https://doi.org/10.31838/jcr.07.06.130

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LIST OF CONFERENCES

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GDP	Gross Domestic Product
RM	Ringgit Malaysia
SSR	Self-sufficiency Ratio
MT	Metric Tons
IDR	Import Dependency Ratio
kg	kilogram
PCC	Per Capita Consumption
KK	Kedah-Kelantan
NAP	National Agrofood Policy
DVS	Department of Veterinary Services
MAFI	Ministry of Agriculture and Food Industry
MARDI	Malaysian Agricultural Research and Development Institute
AI	Artificial Insemination
IBVK	*Institut Biodiversiti Veterinar Kebangsaan*
NGO	Non-Government Organization
FELDA	Federal Land Development Authority
RISDA	Rubber Industry Smallholder Development Authority
FELCRA	Federal Land Consolidation and Rehabilitation Authority
PASFA	Pahang State Farmers Organization
PPNJ	Johor State Farmers Organization
TAC	Target Area Concentration

PINTAR	Permanent Crops/Livestock Project Integration
TRUST	Transformation of Livestock Entrepreneur
ART	Assisted Reproductive Technology
MOET	Multiovulation and Embryo Transfer
IVEP	In Vitro Embryo Production
SCNT	Somatic Cell Nuclear Transfer
BPHH	Best Practice Health and Husbandry
N	nitrogen
EM	Effective Microorganism
VHM	Veterinary Health Mark
SALT	Livestock Practices Scheme
GAHP	Good Animal Husbandry Practices
FFE	Farmer-to-Farmer Extension
TAM	Technology Acceptance Model
TRA	Theory of Reasoned Action
TAD	Transboundary Animal Diseases
FMD	Foot-and-Mouth Disease
HS	Haemorrhagic Septicaemia
HI	High Intervention
LI	Low Intervention
USD	United States Dollar
GAP	Good Agriculture Practices
COVID-19	Corona Virus Disease 2019
EFA	Exploratory Factor Analysis
KMO	Kaiser-Meyer-Olkin

MCO	Movement Control Order
CMCO	Conditional Movement Control Order
TR	Total revenue
TC	Total cost
VIF	Variance Inflation Factor
km	kilometre
M	Mean
SD	Standard Deviation
SPM	Sijil Pelajaran Malaysia
LRGS	Long Term Research Grant Scheme
FGD	Focus Group Discussion

CHAPTER 1

INTRODUCTION

This chapter explains the structure of the beef cattle industry and its recent production. The elaboration continues with the challenges in beef cattle farming, including the scarce pasture land, the low percentage of self-sufficiency ratio and high import dependency ratio of beef. It is followed by the problems that emerged in this area and the justification for using innovation in beef cattle farming. Besides, it also states the research objectives, the scope and the significance of the study. Lastly, this chapter also explains the definition of term used in this study.

1.1 Background of the Study

Malaysian beef cattle sector is diverse with the farm size and structure as well as the performance of its players. It is a significant sub-sector instead of buffalo, goat and sheep in producing protein supply for the population, providing employment and raw materials for the agro-based industry (Kusriatoni et al., 2014). In 2020, the livestock sector was third among other sectors for the Gross Domestic Product (GDP) in the Malaysian agriculture industry, contributing 16.1% of GDP (Department of Statistics Malaysia, 2021). Meanwhile, the cattle population has slightly increased from 657,407 to 659,317 in 2019 to 2020 (Zayadi, 2021).

Despite many strategies implemented by the Malaysian Government to increase beef cattle production by local cattle producers, the beef cattle industry in Malaysia still relies on importation from other countries such as India and Thailand. Hence, the total beef imports in 2020 reached Ringgit Malaysia (RM) 2.2 billion. The incapability of local cattle producers to increase cattle production to meet domestic demand remains the main problem in the beef industry in Malaysia (Jamaludin et al., 2014). Due to this situation, the government has made various efforts to increase beef production and self-sufficiency. However, issues such as low yield characteristics of Kedah-Kelantan breeds, limited land for cattle farming, irregular supply of nutritive feed for cattle and inefficient marketing system are the probable constraints towards the low production of beef (Ariff et al., 2015). Limited land for agriculture, specifically in cattle farming is influenced by the rapid urbanization process in Malaysia, whereas many areas commonly used for cattle farming have turned into residential and manufacturing industry areas (Siwar et al., 2014). This situation is supported by Figure 1.1, where Malaysia also had insufficient issues in pasture land compared to Indonesia and Myanmar. Hence, these two countries can produce a more significant beef production for their populations.

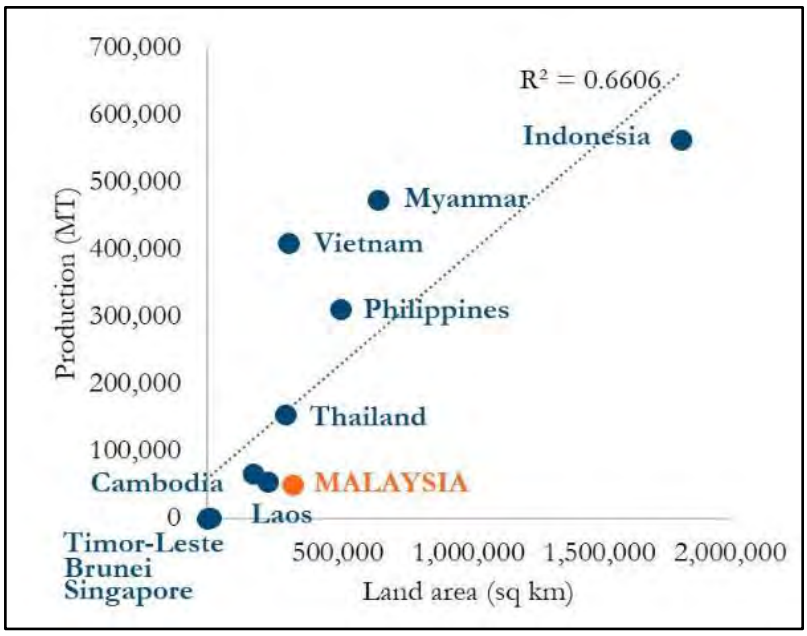


Figure 1.1
Land area versus bovine meat production, Southeast Asian countries, 2017
Source: Ahmad Shaharudin and Tumin (2019)

However, other countries, such as Vietnam can even have more outstanding beef production with 2.7 times more beef production than Thailand and 8.3 times more than Malaysia in 2017 as shown in Figure 1.2.

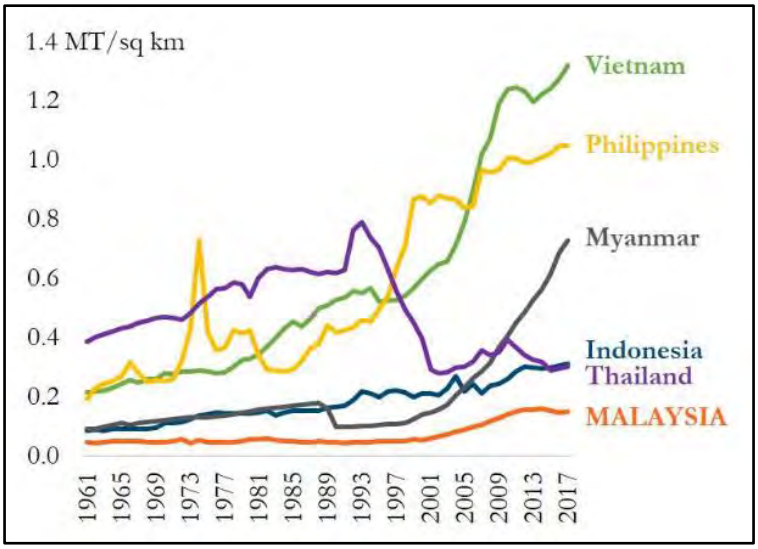
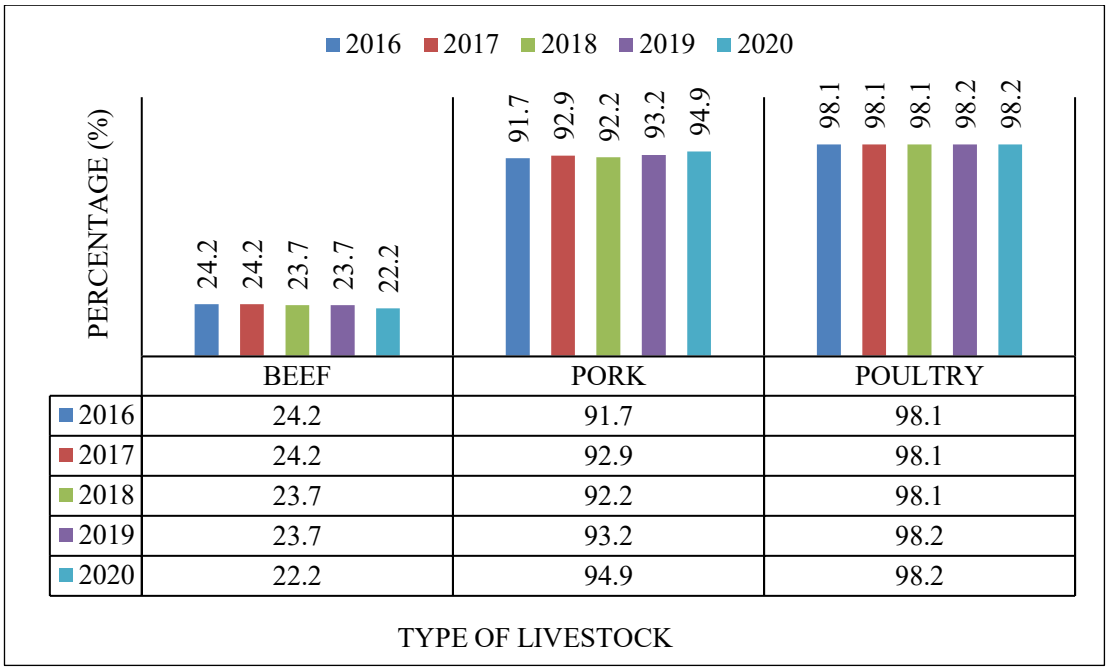


Figure 1.2
Production over country's land area, bovine meat, selected Southeast Asian countries, 1961 – 2017
Source: Ahmad Shaharudin and Tumin (2019)

Cattle production by beef cattle farmers is influenced by various factors such as the amount of capital, land size, good knowledge related to cattle farming techniques and the effectiveness of government assistance (Roessali et al., 2011). Good implementation of innovation in cattle business such as breeding technique, feeding, housing, health care, livestock handling and marketing of cattle-based products can influence the performance of cattle breeders in their business. Cattle farmers need to use specific innovations in cattle rearing management to increase the success of their cattle farming activities, thus achieving the country's aspiration to meet the domestic demand.

In many developing countries including Malaysia, agriculture remains one of the income generators that is essential for livelihood. However, the unsuccessful achievement towards the self-sufficiency ratio (SSR) of Malaysia's ruminant industry was because of the increasing feed price and the difficulty of the breeding stock (Ariff et al., 2015). SSR is understood as the supply of agricultural commodities that can meet domestic demand. If the SSR reaches 100% or more, the agricultural commodities are sufficient to meet local people's demand (Department of Statistics Malaysia, 2019). Figure 1.3 shows a massive gap in SSR percentage between three livestock products: beef, pork and poultry. In 2020, the SSR percentage for beef was only 22.2%, while pork and poultry are far higher, with 94.9% and 98.2% each.



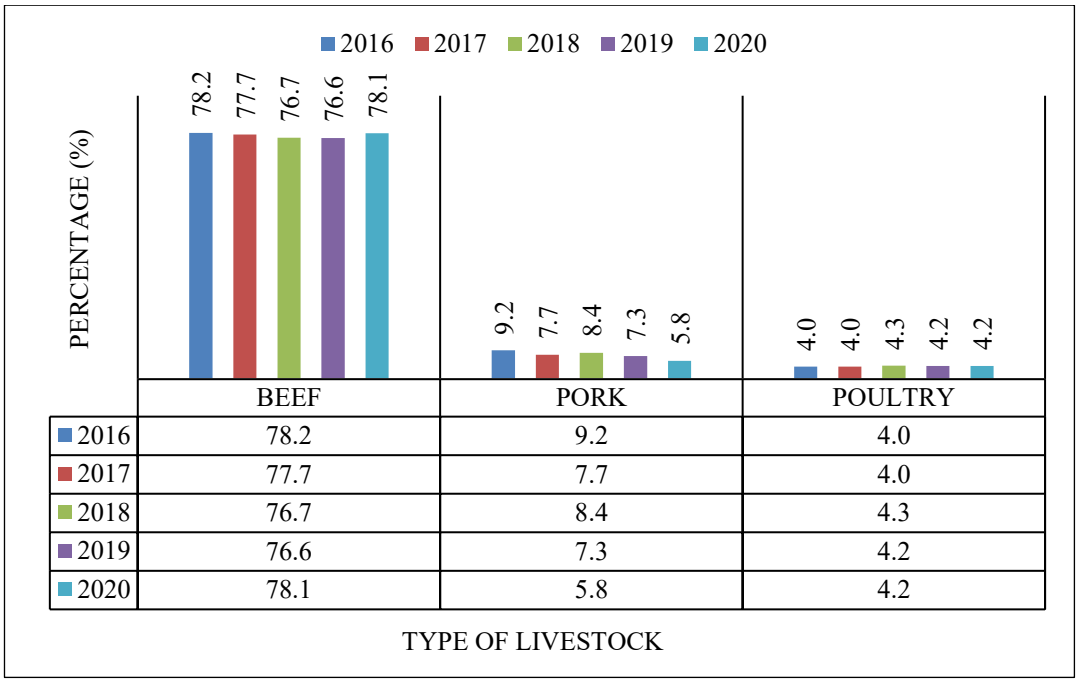
	BEEF	PORK	POULTRY
2016	24.2	91.7	98.1
2017	24.2	92.9	98.1
2018	23.7	92.2	98.1
2019	23.7	93.2	98.2
2020	22.2	94.9	98.2

Figure 1.3

Percentage of Self-Sufficiency Ratio (SSR) for selected livestock from the year 2016 to 2020

Source: Department of Statistics Malaysia (2021)

Additionally, the demand for beef exceeded 201,000 metric tonnes (MT) in 2014, but the production did not exceed 51,000 MT. Hence, another 150,000 MT of beef is needed to meet the population's demand (Hashim, 2015). This situation has led Malaysia to import beef from other countries, which have affected Malaysia's balance of payment. Referring to Figure 1.4, in 2020, the import dependency ratio (IDR) for beef, pork and poultry was 78.1%, 5.8% and 4.2%, respectively. As referred to in the figure, there is a huge gap in the IDR for beef compared to pork and poultry, which remained less than 10% for the three respective years.



	BEEF	PORK	POULTRY
2016	78.2	9.2	4.0
2017	77.7	7.7	4.0
2018	76.7	8.4	4.3
2019	76.6	7.3	4.2
2020	78.1	5.8	4.2

Figure 1.4

Percentage of Import Dependency Ratio (IDR) for selected livestock from the year 2016 to 2020

Source: Department of Statistics Malaysia (2021)

On the other hand, Figure 1.5 shows the extended period of meat supply, ranging from 1961 to 2015. Poultry meat keeps increasing and has become the main source of animal protein. Pork meat supply per capita increased from 16.6 kilogram (kg) in 1961 to 36.0 kg in 1995, before falling to 18.6 kg in 1999 due to the Nipah virus outbreak, while beef supply per capita increased from 2.2 to 5.4 kg per capita.

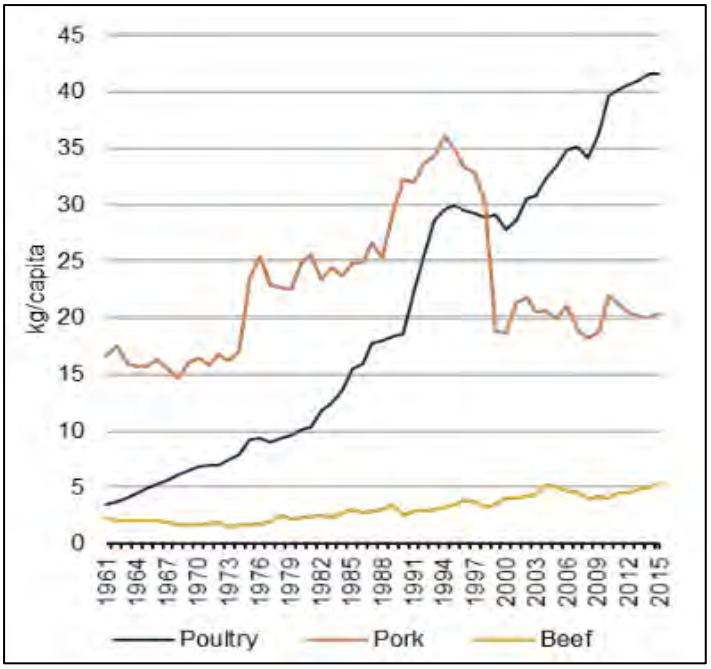


Figure 1.5
Meat supply from 1961 to 2015
Source: OECD-FAO, FAO (various years); Sundaram and Zhai Gen (2019)

Meanwhile, Figure 1.6 demonstrates the increase in the total beef supply where the imported beef is higher than the locally produced. It is noted that almost 90% of local beef production is produced from small farms with few challenges in terms of expensive imported feed, unavailability of appropriate breeds and breeders, low-profit margins and the price competition from the cheaper imported beef (Abdulla et al., 2016).

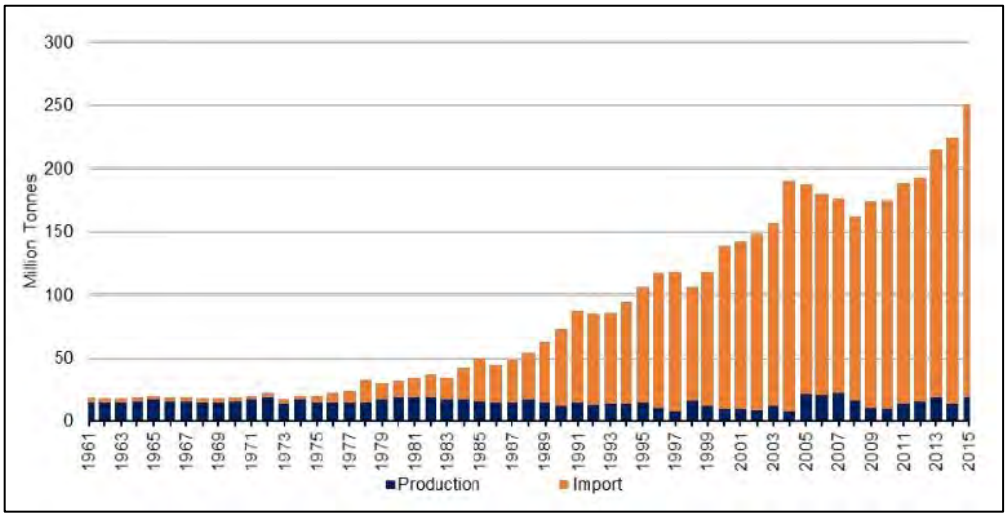
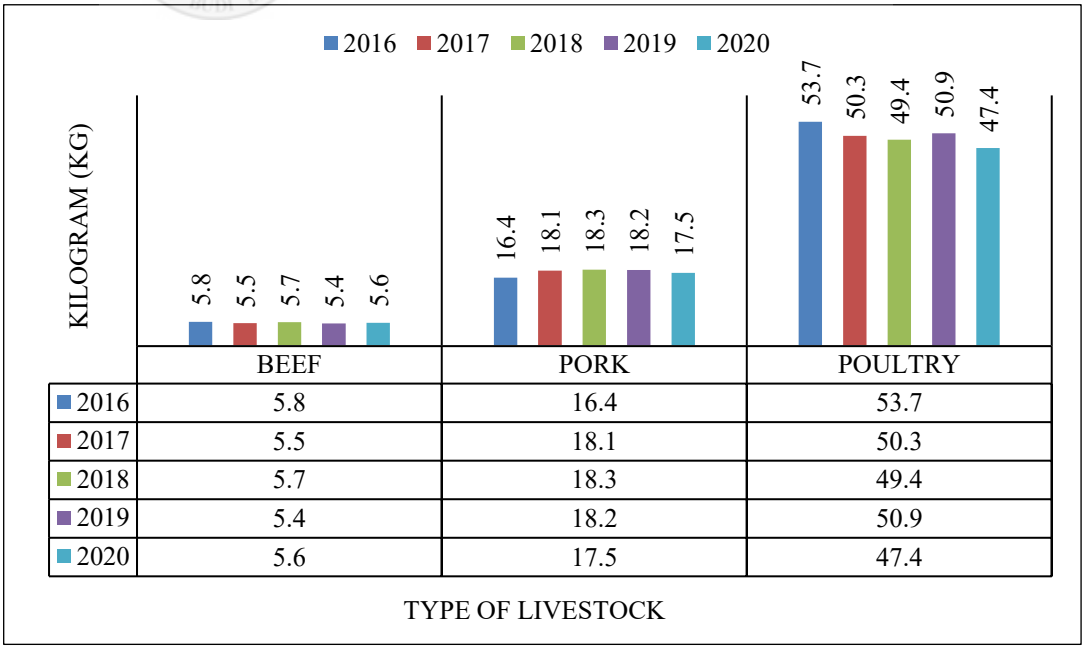


Figure 1.6
Beef production and imports from 1961 to 2015
Source: OECD-FAO, FAO (various years); Sundaram and Tan (2019)

For the per capita consumption (PCC) of beef, pork and poultry, Figure 1.7 shows that poultry meat was the highest with 47.4 kg in 2020, while beef recorded the lowest PCC in the same year with only 5.6 kg.



	BEEF	PORK	POULTRY
2016	5.8	16.4	53.7
2017	5.5	18.1	50.3
2018	5.7	18.3	49.4
2019	5.4	18.2	50.9
2020	5.6	17.5	47.4

Figure 1.7
Percentage of Per Capita Consumption (PCC) for selected livestock from the year 2016 to 2020
Source: Department of Statistics Malaysia (2021)

Breeding cattle in Malaysia is particularly for milk and meat production (Jamaludin et al., 2014). Among the well-known breed is Kedah-Kelantan (KK) cattle, which is small in size, well adapted to the local climate and has a high tolerance of parasites and ticks (Johari & Jasmi, 2009). The KK cattle has become more popular among smallholder cattle farmers as this breed has high fertility and calving rate (Jamaludin et al., 2014). Apart from the Kedah-Kelantan breed, other breeds used by cattle breeders in Malaysia are the Local Indian Dairy breed, Brahman, Droughtmaster and Australian Commercial Cross (Jamaludin et al., 2014; Serin & Hashim, 2010).

The National Agrofood Policy (NAP) from 2011 to 2020 was formulated to focus on improving the food production sector including cattle production. It has three main objectives: first, address food security and food safety to ensure availability, affordability and accessibility; second, to ensure the competitiveness and sustainability of the agricultural-food industry; and lastly, to increase the income level of agricultural entrepreneurs (Ministry of Agriculture and Agro-Based Industry, 2011). Cattle production that can meet domestic demand is crucial to ensure national food security. However, the slow growth rate of domestic cattle production makes the beef industry in Malaysia depend on frozen beef imports. Usually, the price of frozen beef is generally lower as a substitute for local beef. The increased number of imported beef has made the Malaysian government encourage cattle producers to improve cattle production.

Department of Veterinary Services (DVS) is a responsible government organisation under the Ministry of Agriculture and Food Industry (MAFI) concerning the

Malaysian livestock industry, disease control and animal welfare. This organisation also plays a pivotal role in controlling, preventing and eliminating animal diseases, monitoring as well as improving livestock production and animal feed. It also inspects meat, milk, eggs, animal foods, slaughtering houses and animal processing plants. The DVS also controls the import-export activities of livestock, animal products and quarantine services. Besides, DVS provides training for the livestock industries. Last but not least, DVS is continuously researching animal diseases and genetic sources of animals to ensure the animal welfare and conservation of animal genetic materials. DVS has an essential role in the success of the beef cattle farming industry since innovations on suitable farming methods should be given to breeders to enable them to carry out proper breeding activities and provide business profit based on their activities.

Meanwhile, the Malaysian Agricultural Research and Development Institute (MARDI) is another responsible government body with the main objectives of generating and promoting new, appropriate and efficient technologies towards the advancement of the food, agriculture and agro-based industries. Its role focuses more on the research and development of the agriculture industry, including crops, livestock, agriculture engineering and economics. MARDI also acts as a centre for collecting and disseminating information and providing advisory services regarding scientific, technical and economic matters. Besides developing, promoting and strengthening research findings, MARDI also provides extension services to educate Malaysian farmers.

DVS and MARDI put on many efforts to increase ruminant production and reduce beef, mutton and milk imports. This effort is supported by giving more attention to enhancing research in genetic improvement, improving existing breeding techniques, ensuring an adequate supply of animal feed, improving the infrastructure and fixing the small-scale farms (Abdulla et al., 2016). In 2006, MARDI and DVS collaborated to improve the existing breed of KK Cattle. This effort was because the pure breed is becoming extinct due to artificial insemination (AI) programs using the frozen semen from other breeds such as Charolais, Limousine, Droughtmaster and Brahman. After 12 years of research, KK Elit cattle's performance improved, and the maximum weight for the bull increased between 430 to 460 kg and 220 to 250 kg for the cow at the age of three to four years old. The effort to attract more beef cattle farmers to expand the existing population of KK cattle is necessary to avoid extinction and increase this breed's performance. The launch of KK Elit cattle by MARDI and DVS on 14 April 2018 has received many queries and applications from beef cattle farmers in Malaysia to get hold of this improved breed.

The continuous collaboration among MARDI and DVS is vital to ensure a sufficient supply of frozen semen to the targeted farmers. The process was conducted at MARDI Muadzam Shah and *Institut Biodiversiti Veterinar Kebangsaan* (IBVK) Jerantut, Pahang, to collect and freeze the semen as a quality genetic source to increase the population of high-quality KK Elit cattle. However, apart from this effort, beef production in Malaysia is still low, and most ruminant producers, including beef cattle farmers, were categorised as small farm holders. Most of them did not have proper infrastructure and did not grow pastures for the animals than commercial and government farms (Mohamed, Hosseini, & Kamarulzaman, 2013).

Although many efforts have been made by the Malaysian Government and non-government organisations (NGOs) regarding improved farming practices and advanced technologies, this issue has continuously occurred. Innovation is essential to enhance the farm's efficiency, ambitious productions and profitable returns. It also enhances production by improving feed and nutrition technology, livestock management, value-added processing technology, breeding technology and information management (Serin & Hashim, 2010). Proper handling in the livestock management systems and adequate feed supply will enhance farm performance, reduce labour costs and improve animal health.

Due to several issues in beef cattle farming such as uncertain climate, unsustainable and inefficient farming systems have led to low productivity of beef supply in Malaysia. Hence, this study explores the influencing factors towards adopting innovation in beef cattle farming and its economic implications among beef cattle farmers in Peninsular Malaysia. The researcher employed the Diffusion of Innovation Theory and Utility Theory as the backbone of this study.

1.2 The Background of Beef Cattle Farming Sector in Malaysia

Over the years, the policy introduced for ruminant production in Malaysia mainly focuses on importing high-quality breeds, integrating livestock rearing in oil palm plantations, promoting feedlot systems, and developing ruminant feed (Ahmad Shaharudin & Tumin, 2019). The DVS was the responsible government agency in charge of importing high-quality breeds besides carrying out animal distribution and

extension services, including AI. Meanwhile, the land development agencies such as Federal Land Development Authority (FELDA), Rubber Industry Smallholder Development Authority (RISDA), and the Federal Land Consolidation and Rehabilitation Authority (FELCRA), Pahang State Farmers Organization (PASFA) and the Johor State Farmers Organization (PPNJ) had participated in these integration farming programmes. As a result, these agencies have accounted for 15% of the country's cattle production (Ahmad Shaharudin & Tumin, 2019).

Furthermore, from 2016 to 2020, beef population in Malaysia has kept decreasing from 737,827 to 659,317 even though the number of livestock farms for beef cattle showed up as more than half of the total registered farms. Kelantan emerged with the highest number of beef cattle farms, followed by Terengganu and Kedah with 7,060, 4,772 and 2,262 farms, respectively, in 2018 (Zayadi, 2021). According to the Malaysian Breeding Policy (2013), the indigenous breed of cattle in Malaysia is KK, Yellow Cattle KK, Nelore and Brahman. The KK Cattle were found predominantly in the northern states of Peninsular Malaysia and mainly used for beef production. Many farmers consider the Kedah-Kelantan species is the best choice for subsistence farming and integration system with oil palm. In 2020, the SSR for beef is still showing the same patterns with only 22.2%, and it keeps decreasing compared to 2019 with 23.7%. Meanwhile, the IDR in 2020 is also getting higher with 78.1% than the previous year with 76.6% (Department of Statistics Malaysia, 2021). This situation also explains the increasing chicken consumption relative to beef and the complaint that beef has become less affordable (Ahmad Shaharudin & Tumin, 2019).

Beef cattle farming is one of the essential activities in the agricultural sector of Malaysia. This activity plays a pivotal role in supplying beef as one of the protein sources for the population. Most cattle farmers in Malaysia have been employing a traditional farming system since before independence in 1957. During that time, most farmers only had five to ten herds and could only contribute not more than 26% of the national demand (Md. Said & Man, 2014). The constraints in beef cattle farming emerged when there was limited land for farming activities and grazing areas (Ariff et al., 2015). Due to this problem, Malaysia's government has focused on the integration system, and oil palm plantation is the best place to run the activity (Md. Said & Man, 2014). However, the competitiveness of importing beef from India has become the main challenge and has caused beef production growth in Malaysia to slow pace (Hashim, 2015).

On the other hand, the Target Area Concentration (TAC) program has been created by DVS to develop a project based on permanent crops or livestock project integration (PINTAR). This project aims to transform traditional farming into more competitive and highly productive farmers by introducing the Transformation of Livestock Entrepreneur (TRUST) scheme. PINTAR was created to improve the skills and practice of systematic farm management by employing practical and straightforward technologies. The TAC project has given priority to the Malaysian Government regarding animal care and providing extension services. During the mid-term review of the Ninth Malaysian Plan, the Government approved RM 53 million as an additional allocation for developing pens and ranges to enhance pasture quality, which is crucial for cattle production (Government of Malaysia, 2006). However, this project also faced few challenges, such as the limited number of officers in charge as the number

of farmers grew, the bureaucracy in managing the blood test and transfers for cattle breeders, and limited financial resources. Despite the difficulties, there was also proud achievements during the program's implementation, such as the increased number of cattle, more farmers participating in the TAC program, increased participants' income levels, increased employment and business opportunities (Md. Said & Man, 2014).

Meanwhile, a study carried out by Kebebe (2019) on the dairy cattle sector in Ethiopia has found that smallholder farmers repeatedly rejected innovation and new technologies that could benefit their income. This situation was due to several factors, such as insufficient training and knowledge of the newly introduced technologies, weak market linkages and weakened interaction among value chain actors. Yao, Stephen and Sulaiman (2018) also mentioned that most studies had focused on advancing technologies instead of improving the essential farming needs such as ruminant feed and managing composts. Therefore, it is noted that the attention on improved basic training farming methods, program awareness and the effectiveness of the innovation interaction among beef cattle farmers need to be prioritised by policymakers before upgrading the technologies to improve production.

1.3 Types of Innovation in Beef Cattle Farming

Innovation adoption combines several fields of study, including economics, sociology, geography and anthropology. It explains the profitability of the investment, social rewards associated with the adoption and communication channels, spatial differences in resources and the compatibility of the innovation with the norms of the society (Boahene et al., 1999). Therefore, the several disciplines explained above represent

the different aspects of the adoption process. Adopting innovation is a multi-dimensional process including perceived relative profitability, costs of establishment, compatibility with value systems and ease of communication (Boahene et al., 1999). There are types of innovations in beef cattle farming that have been introduced by scholars, including assisted reproductive technology, forage technology and converting crop residue as feed. The detailed explanations of innovation can be seen as follow:

1.3.1 Assisted Reproductive Technology

Scientists created many innovations in cattle farming to ease the farming process and improve production, which will encourage people to engage in cattle farming and become beef producers. Assisted reproductive technologies (ART) is one of the innovations in cattle farming, including AI, cryopreservation of gametes and embryos, multiovulation and embryo transfer (MOET), in vitro embryo production (IVEP) and somatic cell nuclear transfer (SCNT) (Paramio & Izquierdo, 2014). AI is known as the first introduced reproduction technique in the 1890s. The AI procedure involves injecting bull semen into the cow uterus using the respective tools for the AI to obtain rapid livestock genetic improvement and production (Yimer et al., 2015).

In Malaysia, this technique is most commonly used for breeding as it has a high probability of conception rate and can produce great crossbred calves (Basunathe et al., 2010). Besides, relevant agencies related to cattle farming also deliver AI services among cattle farmers. However, not all farmers are ready to employ AI due to socio-economic factors like poor extension services, less formal education and low standard

of living (Rathod, Chander, & Sharma, 2017). This technology, however, still raises the question of either it is the solution or the challenges in the ruminant sector. The challenges continue as a farmer must have knowledge, skills and high-cost facilities. Hence, all stakeholders, including the farmers, policy-makers and extension workers, are significant to ensure the continuity of this sector.

1.3.2 Forage Technology

Napier grass is one of the accessible feed sources for livestock, especially ruminants, and the introduction of an improved Napier has brought new hope among farmers. In Malaysia, Pahang, Johor and Negeri Sembilan were the top producers of Napier grass in 2017. The most common variety of Napier grass among farmers in Malaysia are Common Napier, Red Napier, Indian Napier, Uganda Napier, Taiwan Napier, Dwarf Napier and Australian Dwarf Napier (Halim et al., 2013). In choosing the variety of Napier grass, farmers must consider the protein content, ruminant's digestion process and productivity (Haryani et al., 2018). Napier grass has recently become the alternative feed source since the pellet price has spiked. From the year 2007 to 2013, the responsible agency in Cambodia conducted a project known as 'Best Practice Health and Husbandry of Cattle, Cambodia' (BPHH) to identify forage technology as a mechanism to enhance large-ruminant productivity and improve the standard of living among smallholder farmers in rural southern Cambodia (Ashley et al., 2018).

Besides, forage technology can also improve the quality of forages and support the current supply as the planting period only takes two months to be harvested. The villagers in the area of Kampong Cham Province also gained a good advantage by

adopting this innovation. Smallholder farmers who had adopted improved forages have increased their cattle production, and most importantly, the time savings with children have improved their school attendance (Maxwell et al., 2012).

1.3.3 Feed Technology

The adoption of a robust feeding system is also known as one of the innovations. Rice and corn straw is the substitution of feed supply for beef cattle farmers due to the shortage of native pastures (Baba et al., 2019). The utilisation of crop residue as a feed also can support the increasing number of beef cattle at the farm. Meanwhile, urea treatment on a corn stove is another effort by scientists to enhance the nutritional value of crop residues for effective utilisation (Mudzengi et al., 2014). The use of salt block supplementation can also avoid mineral deficiencies in cattle. However, this approach is not practical as most of the salt blocks available in local markets are imported from other countries, and do not provide all the minerals needed by the cattle. Under this condition, Panadi et al. (2018) mentioned that urea-molasses mineral blocks or medicated urea-molasses mineral blocks supplementation are suited for the animal and complete with macro-micro minerals, nitrogen (N) and high energy.

On the other hand, the conversion of Napier into silage can also become a source of feed. The use of silage is crucial among farmers in the east-coast region of Peninsular Malaysia during the monsoon season. The fresh Napier will undergo fermentation with an effective microorganism (EM) or molasses for 21 to 28 days before use. Making silage is done manually by smallholder farmers, while medium and large enterprise farmers commonly employ a commercial machine. MARDI has innovated a silage

processing machine named OTOSIL. This machine can reduce 22% of production cost and increase 12% of the quality of silage. Hence, these efforts would help beef cattle farmers to overcome the problems of limited feed sources and the uncontrolled market price of feed.

1.3.4 Biosecurity

Generally, biosecurity is essential in beef cattle farming to ensure the cattle's health and prevent unwanted diseases. Biosecurity includes administering pens such as vaccinations, animal traffic management and sanitation (Lestari et al., 2019). The purpose of enhancing biosecurity among beef cattle farmers is to avoid disease transmission to humans, including Anthrax (Lestari et al., 2019). Proper farm management is crucial in a farm as it includes good feed sources, guarantees safety and minimises losses to the farmers. Meanwhile, environmental management such as garbage disposal, drainage and sewage is also an important matter that must be given attention on the farm (Suppadit et al., 2006).

1.3.5 Vaccination

Vaccination is also one of the innovations in cattle farming. Farmers who are aware of producing healthy cattle will take the vaccine to prevent any possible diseases. Basunathe et al. (2010) supported in their study that more than half of the farmers have moderately and wholly vaccinated their animals for several reasons, such as prevention from infectious diseases and ensuring healthy cattle. In a study by Serin and Hashim

(2010), about 73% of the farms surveyed conducted vaccination programs while 65% had blood screening and 35% of farms achieved Veterinary Health Mark (VHM) accreditation. However, only 17% of the farms were awarded the Livestock Practices Scheme (SALT). The recognition of SALT is based on several criteria: fulfil the Good Animal Husbandry Practice (GAHP), Animal Health Management, implementation of biosecurity at the farm, good infrastructure and veterinary medicine control.

1.3.6 Intensive Rearing Technique

The limitation of land use is one of the challenges in beef cattle farming. The intensive rearing technique leads farmers to overcome problems regarding the limited grazing area (Baba et al., 2014). In this era, land competition has become a significant problem within the manufacturing and services industry. Thus, by adopting intensive rearing techniques, farmers can control their farm as the beef cattle are reared in a restricted area to ensure good health, high-quality feed for cattle, proper sanitation process and better management of waste. Robing activity can also be avoided since the cattle are safe in their respective area.

1.3.7 Integration Rearing Technique

Cattle farmers in several countries have been widely practising the integration rearing technique. The integration occurs commonly in a palm oil plantation where palm oil crops integrate with cattle and complement each other. This method has many advantages, including reduced cost of weeding by more than 50% and increased fruit

yield as there is a lack of competition between the grass and palm oil trees (Md. Said & Man, 2014). Figure 1.8 below shows the key aspects of integrated farming systems where the crops and livestock benefit each other and produce a holistic management system (Reddy, 2016).

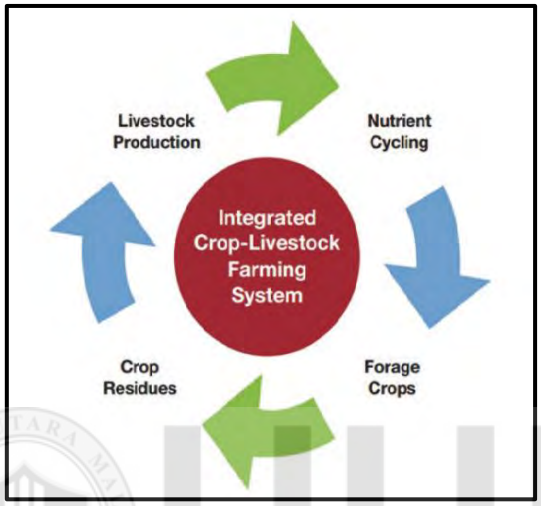


Figure 1.8
The key aspects of integrated farming system
Source: Reddy (2016)

Furthermore, the farmers' income has also possibly increased due to the high production of palm oil fruits and allowed the sale of beef cattle (Md. Said & Man, 2014). The sufficient area for grazing will make the beef cattle graze freely, with open spaces between the rows of palm trees. Thus, less cost is needed for clearing, planting and fertilising grass pastures (Md. Said & Man, 2014).

1.3.8 Composts

Innovation does not only rely on technologies themselves. It also covers the improved and current farming methods. Generally, waste management in livestock is divided

into domestic waste and livestock waste. Non-organic domestic waste is managed through 3R (recycle, reduce, reuse) concept, whereas livestock waste is categorised as organic waste such as the cattle's urine, faeces and the leftover of cattle's feed sources. Adopting organic waste as fertiliser emerged as an agricultural innovation where the crop farmers utilise it onto their farm. Several cattle farmers have realised that cattle's waste will make an effort to transform into organic fertiliser to generate more income and improve their livelihood. Paul et al. (2017) found that most farmers adopted and applied organic fertiliser compared to chemical fertiliser. However, several factors may hinder the farmers from adopting this innovation, such as the labour shortage and lack of knowledge for compost processing (Supaporn et al., 2013). Hence, ongoing maintenance and monitoring of the farm are essential to ensure maximum sustainability.

1.3.9 Biogas Technology

Biogas technology is an emerging technology nowadays. This technology involves anaerobic digestion process by converting organic waste, including cattle manure, into biogas (Wahyudi, 2017). Employing biogas technology can reduce the households' expenditure, enhance income generation, and create job opportunities among the local people (Haryanto et al., 2017). Besides, biogas can also generate clean energy by inhibiting methane and ammonia as well as reducing environmental pollution. However, the cost of construction and biogas management is very high compared to the price of livestock, which poses a significant challenge for beef cattle farmers.

1.3.10 Entrepreneurship

Entrepreneurship is another crucial element in innovation. Farmers must be able to manage impactful activities and organise the production besides the process of distribution (Kebebe, 2019). On the other hand, smallholder farmers who are typically weak and refuse to engage in commercial beef production are commonly lack marketing knowledge and do not approach farming as a business (Kebebe, 2019). However, de Janvry et al. (1991) suggested that poor performance of smallholder farmers towards profitable production could be an issue beyond their control other than lack of entrepreneurial capacity. Furthermore, systematic record-keeping is also crucial for the farm's decision process but was found less demanding among beef cattle farmers in Peninsular Malaysia (Serin & Hashim, 2010).

On the other hand, some scholars believed that smallholders' low entrepreneurial capability is due to cultural issues and social systems (Tanguy et al., 2014). Some of the smallholders in Ethiopia usually fail to make investments despite a high return as they have low aspirations. This situation happened due to their cultural traditions accepting whatever they have and believing it is destined to be in the current state. Therefore, low entrepreneurial capacity among smallholder farmers is assumed to be linked to socio-economic, cultural and political issues (Kebebe, 2019).

Innovation in cattle farming could help cattle farmers to maximise their profit by lowering the cost of production. It will also improve the standard of living among cattle farmers and decrease the import value of beef. However, to achieve a higher production input, a farmer must have the right attitude in handling farming activities

and be mentally prepared to face future challenges. Hence, before considering technology adoption, a farmer requires sufficient capital to purchase the technological inputs and family labour to manage the farm besides the sufficient land for the improved forages to ensure that it will not compete with staple crop production (Ayele et al., 2012). Furthermore, households also require a reliable value chain to ensure the access of technological inputs supply such as supplementary feed at a reasonable price, reliable access to AI, an excellent extension service, easy access to credit, insurance and assured markets to sell beef before considering technology adoption (Bernard & Spielman, 2009; Jaleta et al., 2013). Kay et al. (2016) also added that financial analysis of a farm is vital to ensure healthy spending for the inputs and outputs. The farm's profitability and efficiency, including the production cost, total revenue, liquidity, and solvency, are vital to ensure the farm can survive in the long run.

1.4 Problem Statement

Beef cattle farming in Malaysia is an essential activity in the agricultural industry. Farmers' ability to produce high productivity can influence their success in this ruminant sector. However, since beef cattle farmers are diverse in terms of farm size, skills and financial conditions, the adoption of innovation and their ability to increase cattle production will also be varied. The performance of the sector also remains unsatisfactory, and limited thorough impact evaluations on the contributions of such innovations. It is interesting to know factors influencing the adoption of innovation by beef cattle farmers in Malaysia and the financial performance of this activity, including profitability and efficiency. At the same time, it is expected that rearing techniques

and the herd size can influence innovation adoption and affect their economic performance in terms of farm business profitability and efficiency.

For many years, low SSR and high IDR have become the primary concern in food security issues. Besides, climate change has also been noticed as a threat to the livestock industry, specifically in feed production. Due to this issue, innovation regarding improved feed such as silage for the cattle is crucial. This action will spark up farmers' interest in minimizing the risk of losses. Moreover, unsustainable cattle raising and low beef production have also caused the adoption of the integrated farming system. The agricultural and livestock activities are carried out in the same compound, and it is believed that it would provide agronomic and ecological benefits as well as economic advantages in the future. The unsatisfactory performance in agriculture production is due to several factors, such as limited land, leading to inadequate economic viability and poor market integration. Hence, disseminating information regarding innovation and encouraging farmers to adopt it is vital to accelerate economic growth, diminish food insecurity and lessen poverty.

Scientists worldwide have introduced several types of innovation, such as ART, agricultural by-products as animal feeds and converting cattle waste into organic fertiliser. The dependency on the conventional method such as natural mating for breeding and the high reliance on forages will lead to inefficient farming activity with low production. The high-quality breed cannot be produced, and sustainability cannot be achieved. Sustainable agriculture will complement all agricultural activities, including the crop waste that can turn into cattle feed and silage. This innovation was created to enhance beef production and improve farmers' livelihood. However, the

unfavourable income and not being well exposed to the latest technique in rearing beef cattle have become barriers to adopting the innovation. Thus, it is crucial to study the relationship between the adoption of current technologies with the farmers' economic performance.

Traditional farming or range feeding, integration and feedlot are the three standard farming methods practised by beef cattle farmers in Malaysia. Typically, smallholder farmers dominate this sector, and they usually hold a small number of beef cattle, which are less than 50 heads on their farm. Good practice in rearing beef cattle is fundamental to achieve high returns and productivity. Regardless of other factors such as price and costs, most farms with poor agriculture practices are expected to be hard to earn profit from their farming activities. The animal unit returns are significant in a business where most farm receipts come from beef cattle sales, and the highest profit comes from well-balanced business practices. Smallholder farmers should have a reasonable farm size to provide the economical use of land, labour and up-to-date technologies. Integration farming is the most preferred method for cattle farming as it involves intercropping and improving soil biological diversity, controlling weeds, insects and disease populations.

The TAC programme launched by the DVS was a successful project with good cooperation from the farmers. It is proven that the integrated farming system between cattle and oil palm plantation practice had a positive impact on production, income, employment, changes in knowledge, skill, attitude, and practice. However, the limited knowledge of animal feed and poor husbandry handling can reduce beef cattle farmers' productivity. Poor disease control and insufficient resources, including market

information, market linkage and finance, have also led to a decline in beef production. Introducing innovation in the agricultural sector can increase the productivity and income of the farmers. However, not all innovations will economically impact beef production, and there appears to be limited empirical evidence to support this statement (Elias et al., 2013). Then, knowing which innovation is crucial in beef cattle farming is essential.

Disseminating information regarding innovation in beef cattle farming is vital to ensure knowledgeable and skilful farmers. Referring to the personal interview with veterinary officers and beef cattle farmers, insufficient knowledge and skills among smallholder farmers have become the main challenges to improve beef cattle production and ensure the nation's food security. Adequate knowledge and skills transmission, including frequent monitoring from veterinary services, will require Malaysia's Government's high expenditure. Hence, the participation of farmers in sharing the information within their circles is crucial. This situation is also known as a farmer-to-farmer extension (FFE), which has been effectively practised by farmers in several countries in East Africa, such as Uganda, Kenya and Rwanda. Several scholars have reported that FFE could help farmers improve beef production and does not involve high government spending. However, it also potentially inhibits innovation adoption if not well understood and addressed. Davis (2008) mentioned that there is not much evidence on the newly introduced models, extension reforms, and pluralistic models involving various extension providers. A study on the impact of FFE on adopting new technology and improving beef cattle production by individual farmers is essential for food security.

Much research has focused on adopting high-cost technologies such as high yield of cattle breed in identifying agricultural innovation literature. Unfortunately, little attention is given to the impacts of improved elemental farming methods like compost and integration farming. The advancement of basic farming methods is also considered innovation as it provides changes from the previous farming practices. Besides, research on the impacts of adopting innovation to improve productivity and increase farm efficiency has remained relevant over the years among academics and policymakers (Ogundari & Bolarinwa, 2018).

Research results from this study would be beneficial to identify strategies in beef cattle farming to enhance cattle production in the future. The extension services must assist beef cattle farmers, whereas the government could implement strategies to lead a structural change in the beef cattle industry. Hence, it is crucial to identify the relationship between the influencing factors on profitability and efficiency of beef cattle farming in Malaysia.

1.5 Research Questions

This study has four research questions as stated:

1. What is the socio-economic status of beef cattle farmers in Peninsular Malaysia?
2. What is the profitability and efficiency in beef cattle farming according to the region, herd size, and types of innovations?

3. How is the economic implications of innovation adoption in beef cattle farming in terms of farm performance?
4. What are the factors that influence the adoption of innovation in beef cattle farming?

1.6 Research Objectives

For the research objectives, this study comprises main and specific objectives as below:

1.6.1 Main Objective

The main objective of this study is to determine factors affecting the adoption of innovation and its economic implications in the beef cattle industry in Peninsular Malaysia.

1.6.2 Specific Objectives

1. To identify the socio-economics status of beef cattle farmers in Peninsular Malaysia.
2. To examine the profitability and efficiency in beef cattle farming by region, herd size, and types of innovation.
3. To examine the economic implications of innovation adoption in beef cattle farming in terms of farm performance.

4. To analyse factors that influence the adoption of innovation in beef cattle farming.

1.7 Scope of the Study

The respondents in this research included registered and non-registered beef cattle farmers with the DVS in Peninsular Malaysia. Beef cattle farmers from Johor, Selangor, Kedah and Kelantan were selected as the respondents in this study. These beef cattle farmers represented the southern, central, northern and east-coast regions of Peninsular Malaysia. Several farmers did not register with DVS but performed well in beef cattle farming by employing such innovations. The innovations include AI, which is commonly practised by farmers in the east-coast region such as Kelantan, Terengganu and Pahang. Besides, the innovation in beef cattle farming includes vaccination, supplementation and improved forages.

Many beef cattle farmers in Peninsular Malaysia practice rearing techniques such as feedlot and integration. These two systems are more systematic and relevant in terms of productivity and quality than the previous traditional farming technique. The management of cattle waste and converting it into compost has gained popularity among beef cattle farmers, while the skilful and knowledgeable farmers have made the compost and sold it to the other crop farmers.

1.8 Significance of the Study

Beef cattle farming is one of the critical activities to ensure economic development in Malaysia. This activity is essential to assure food security and as a source of income among farmers. This study attempts to contribute to work with DVS by exchanging information about the adoption of innovation in beef cattle farming and preparing a holistic database of beef cattle farmers in Peninsular Malaysia. Several discussions and recommendations also highlighted the potential needs and areas of concern, including low-income farmers and farmers' associations. FFE is one of the current approaches to disseminate innovation information among farmers. Hence, the FFE was added and tested into the research framework to measure whether or not it can influence beef cattle production. The economic factor was also measured to discover the impact of innovation.

This study will contribute to the practice in terms of improving the existing approach and policy. The data gained can be the guidelines for DVS on adopting improved farming methods and the current technologies in beef cattle farming. This effort is to achieve sustainable agriculture practice where farmers can decrease the loss of output and increase their income.

Next, this study can contribute to the policy that identifies the influencing factors among beef cattle farmers on adopting innovation. Accordingly, exploring the influencing factors can offer valuable data for related parties such as DVS and MARDI to develop and plan the best strategies for developing and sustaining the beef cattle

industry particularly in Malaysia. This effort can also educate farmers towards best farming practices for better livelihood.

1.9 Definition of the Key Term

1.9.1 Adoption of Innovation

Adopting innovation is understood as employing an improved farming method or advanced technology such as ART, agricultural by-products as animal feed and converting waste into compost. Farmers must undertake these efforts to ensure an increase in beef productivity. Besides, these practices will also help farmers increase their income and ensure food security. Furthermore, the linkage between researchers, extension agents and farmers must be keen to ensure that agriculture information is well-disseminate.

1.9.2 Beef Cattle Farming

Beef cattle farming is an activity conducted by a farmer who is rearing beef cattle for self-satisfaction or business purposes. People in rural areas usually own beef cattle to slaughter during any occasion, such as a wedding or thanksgiving ceremony. Besides, some of them also do this activity to generate more income and have a better standard of living. There are three types of rearing techniques for cattle: range feeding, integration and feedlot.

1.9.3 Extension Service

The government agencies such as DVS and MARDI aim to assist beef cattle farmers in their farming activities. The skilful and knowledgeable extension agents are responsible for guiding farmers about the current innovation and distributing the related information on farming activity. However, there is another extension service approach among the committees of beef cattle farmers. A farmer-to-farmers extension service is an extension activity conducted by farmers to distribute the latest innovation among their circles. This approach potentially builds trust among the community of farmers and allows them to improve their livelihood.

1.9.4 Access to Information

The accessibility to information is vital to access the updated skills and knowledge on beef cattle farming. Farmers who have easy access to receive information usually get higher productivity than those who are not. Access to information has different measurements, such as the distance from farm to extension office or the facilities owned by a farmer including an internet connection and smartphone. These facilities are essential to achieve precise and accurate information for beef cattle farming.

1.10 Organisation of Thesis

The first chapter discusses the study's background, including the agricultural industry, the beef cattle sector and food security issues in Malaysia. The following sub-topic explains the problem statement, research questions, objectives, scope, significance of

the study and limitations. Lastly, the definition of key terms is to elaborate on the terms used in this study.

Meanwhile, Chapter 2 covers the related studies previously conducted and the discussions on underpinning theories. Chapter 3 describes the methodology, including the research framework, sampling procedure and data analysis. Finally, chapters 4 and 5 present the findings, discussion, conclusion and recommendations for future study.

CHAPTER 2

LITERATURE REVIEW

This chapter covers an explanation of adopting innovation in agriculture, the factors that influence innovation, besides the theories involved as a foundation of this study. The explanation also consists of empirical studies on innovation adoption in beef cattle farming. Furthermore, it elaborates on the stages in the decision-making process and the use of the theories in this study. The methodology was also reviewed based on the studies that have been conducted in various countries, including Indonesia, Caribbean Island and Cambodia. Finally, this chapter ends with a summary.

2.1 Definition and Concept of Adoption of Innovation in Agriculture

Innovation is understood as a new practice, idea or object. The newness in innovation does not only involve new knowledge. It also happens when someone has known of innovation for quite some time but has yet to develop a favourable or unfavourable attitude towards it. On the other hand, the "newness" form of innovation is the probability to express in the aspect of persuasion, knowledge or a decision whether to adopt or not. Innovation and technology are commonly known synonyms, where technology is a tool to increase job task efficiency and benefit those who employ it.

Furthermore, the adoption of the innovation and agriculture sector cannot be separated. The improved method of farming and the introduction of new technologies aim to boost agriculture productivity. However, according to Yao et al. (2018), the adoption of technologies among smallholder farmers in developing countries has been slow. It was then further supported by Duflo et al. (2008) that smallholder farmers in Sub-Saharan Africa have low adoption of current technologies and improved farming methods. Hence, this situation has led to low agricultural productivity (The World Bank, 2008).

According to Naseem et al. (2010), science and technology have played the primary role in promoting economic growth and enhancing living standards among rural communities, including the farmers' community. However, agricultural production in some producing countries is getting low. Referring to Benyamin (2019), agricultural innovation has been given priority during the Green Revolution era to solve malnutrition and the global hunger crisis. Therefore, technological development, such as fertiliser to improve soil fertility and proper irrigation for growing crops, has been given more attention to increase food production and agriculture scale. Unfortunately, although several technologies have been designed to ensure efficiency in food production, some issues still showed that the technologies are not environmentally friendly and cost-effective for individual farmers in poor and middle-income countries.

2.2 Factors Influencing Adoption of Innovation in Beef Cattle Farming

Many factors potentially influence farmers towards the adoption of innovation. Socio-economic factors such as age, education level and experience were the common factors

used by scholars, while the distance to veterinary extension centre, off-farm employment, herd size and farm size were also measured. The efficiency of extension providers, such as the government agency and farmers' association has been identified as a significant factor. Total working hours, access to information and income have also been proven as one of the influencing factors towards innovation among farmers.

In many studies done by researchers, age is a vital factor that influences the adoption of innovation among farmers. Young and energetic farmers are tolerant and ready for the new transition regarding farm activities, while the ageing farmers refuse and are not ready for any changes to adopt an innovation (Paul et al., 2017; Suvedi et al., 2017). However, this finding contradicted Baba et al. (2019) and Roessali et al. (2011) that age does not play a significant role in adopting innovation. It is also understood that farmers with any age range tend not to adopt innovation at their farms.

Education level also influences farmers to adopt innovation in beef cattle farming. Farmers with higher education backgrounds are commonly willing to learn new knowledge and practices. Unfortunately, farmers with no education background are yet to be ready for the current practices as they thought it would risk their farming activity (Ajewole, 2010; Folefack, 2015; Paul et al., 2017). In contrast, Roessali et al. (2011) found that education level is significant with a negative relationship in adopting innovation to increase the business scale. Most educated people do not have enough time to work at the farm with beef cattle, and they choose to be in a prestigious sector with a high salary (Hartono et al., 2005). Meanwhile, education has been also found as insignificant and did not influence farmers to adopt innovation in beef cattle farming (Baba et al., 2019)

The experience in farming activity can affect farmer's attitudes in adopting the new practices (Ajewole, 2010; Bamire et al., 2002). A study by Paul et al. (2017) found that young farmers who lack experience, skills and practice tend to adopt innovation, while the older farmers with more fabulous experiences find it hard to receive changes and deviate from innovation. On the other hand, Baba et al. (2019) and Wahyudi (2017) found that farmer's experience does not influence the adoption of innovation in cattle farming. It means that either the farmers have had fewer or greater years of experience, they are still not interested in adopting innovation at the farm.

Farm distance to veterinary extension centres also plays a vital role in innovation adoption. Rathod et al. (2017) stated that farm distance to the veterinary extension centre is significant with a negative relationship on the adoption of innovation. More farmers are away from innovation with the increase in the farm's distance to the veterinary extension centre. Furthermore, Long et al. (2016) stated that off-farm employment is essential and has become one of the determinants to measure how a farmer supports the cost of the farm. Folefack (2015) found that farmers with off-farm activity are less likely to adopt innovation than full-time farmers. This argument was supported by Suvedi et al. (2017), who argued that off-farm employment has hindered farmers from attending training and programs on agricultural innovation. Hence, this situation can cause them away from adopting innovation in cattle farming.

Besides, farm size is another variable measured in innovation studies instead of family labour and off-farm activities. These variables are also identified as essential to support the cost of the farm (Feder & Umali, 1993; Long et al., 2016). The bigger the farm

size, the more capital farmers have to invest in the farm activities. Ajewole (2010) stated that farm size is significant with a negative relationship on the adoption of innovation, meaning that when the farm size is smaller, it makes the farmers adopt innovation onto their farm. Meanwhile, Baba et al. (2019) also stated that farm size has a significant and positive effect on adopting agricultural residue as cattle feed. However, Paul et al. (2017) and Sotamenou and Parrot (2013) have different findings that farm size is insignificant in innovation studies.

On the other hand, herd size or the number of cattle also plays a vital role in influencing beef cattle farmers to adopt innovation. Three studies conducted in Indonesia regarding innovation in beef cattle farming found that herd size significantly influenced the behaviour in adopting innovation such as intensive rearing technique, agricultural bi-products as cattle feed and biogas technology (Baba et al., 2014, 2019; Wahyudi, 2017). Meanwhile, a study in India by Rathod et al. (2017) also found that herd size significantly influenced farmers in adopting AI to improve the farm's production.

Extension services provided by the Government aims to assist farmers with agricultural innovation to improve their agricultural output and income. Baba et al. (2019) stated in their finding that government extension services had influenced farmers to adopt agricultural innovation. Unfortunately, Lestari et al. (2019) found that government support in an extension program did not effectively work among cattle farmers in South Sulawesi Province Indonesia. Baba et al. (2014) also added that extension service does not influence the adoption rate of innovation in cattle farming. Hence, Suvedi et al. (2017) have concluded in their study that the extension system

will not be functioning right if there are limited innovative activities and ineffective communication between farmers and extension workers.

Some studies found that farmer-to-farmer extension is the factor in adopting innovation. This approach can attract local farmers to adopt the updated skills and practices in cattle farming due to their proficiency in the local condition, culture and practices besides the trust gained from other farmers (Kiptot et al., 2016). Furthermore, the farmer-to-farmer extension has played an alternative role in spreading agricultural innovation and facilitating farmers' production. In a study in South Sulawesi Province, Indonesia, beef cattle farmers adopted agricultural innovation from year 2006 to 2008 after some farmer's association members began to adopt it in 2001 (Baba et al., 2014). Besides, the farmer's association tended to act as the best example for the other beef cattle farmers and put themselves as a trusted person within their social system (Heong et al., 2002; Manner & Gowdy, 2010).

On the other side, the NGO has gained popularity in extension services due to their contribution in assisting the local farmers, but maintaining the services' quality is a big challenge (Suvedi & Ghimire, 2015). The farmer-to-farmer extension has been recognised as a vital factor in innovation studies. Hence, several researchers found it significant to influence farmers to adopt innovation (Baba et al., 2014, 2019; Paul et al., 2017).

Scholars also measured working hours in determining the adoption of innovation. In a study by Kamarul Zaman (2018), the total working hour was a significant and negative relationship towards adopting innovation. This situation was supported when the

farmers found that adopting innovation has made their tasks more manageable, and they did not have to spend for a more extended period at the farm. Access to information is also the determinant in adopting innovation (Luo et al., 2014; Marra et al., 2003). A strong relationship with extension agents, farmers' associations and research centres can lead to easy access. Paul et al. (2017) found that information access is significant in adopting innovation. This finding is similar to Folefack (2015) stating that disseminating information is great if research institutes and extension agents work together for information dissemination. However, the finding by Rathod et al. (2017) contradicted Folefack (2015) and Paul et al. (2017) as information sources among cattle farmers in India was not significant towards the adoption of innovation.

The researchers often use social status or generally been measured as income to determine factors towards adopting innovation. Wahyudi (2017) mentioned that a good social status with a higher income among cattle farmers in Pati, Indonesia has led them to adopt biogas technology at their farm. Roessali et al. (2011) also added that income is significant with a negative relationship to increase beef cattle business scale. The farmers consider this situation as they do not have sufficient space and limited feed source to have a greater number of beef cattle. Hence, farmers refuse to increase their business scale and might be away from adopting innovation in beef cattle farming. However, Kamarul Zaman (2018) argued by mentioning that farmers' income is insignificant on innovation adoption among paddy growers in Peninsular Malaysia.

2.3 Utility Theory

Utility Theory is one of the early theories in economics discussing decision making by the decision-makers (Edwards, 1954). Utility theory was introduced by Jeremy Bentham, who was a moral philosopher. His theory got its popularity by James Mill and was widely used by famous economists including Marshall and Jevon. This theory is also a branch of knowledge in economics for evaluating an individual's level of satisfaction over something (Edwards, 1954).

Utility theory focuses on the decision made by the decision-makers. Thus, this theory is used to measure the decision towards the acceptance of innovation. Furthermore, some previous literature discussed the definition of utility, where the goal of decision-makers in an economic system is to maximise the financial returns earned by minimising costs and maximising output (Von Neumann & Morgenstern, 1947). Besides, Rahm and Huffman (1984) also added that utilities are not only in financial form but are also defined as non-monetary such as the advantages of new technologies compared to the old technologies.

On the other hand, farm business analysis is essential and has been used to measure farm's financial progress to decide on adopting innovation. The analysis is divided into four investigation areas: profitability, farm size, financial and efficiency (Kay et al., 2016). Farmers need to focus on profit performance with acceptable operating costs to ensure that the cattle businesses can survive in the long run. Financial performance can be influenced by the revenue and stock appreciation of the business entity. Profitability is usually analysed by comparing the total revenue and expenses. High

income is an important goal of each farmer, while farm size is defined as one of the farm resources. Inadequate resources can lead to low profits. However, rapid growth and exceeding the size may also cause inefficiency and reduce profit as well. Financial analysis can be determined by analysis of profitability, liquidity and solvency. Profitability can be analysed by looking at return on assets, equity and sales (Kay et al., 2016).

Meanwhile, liquidity refers to the extent to which debt commitments may be met by the cash or other financial assets that are due over the next 12 months. It shows the capability of a business to convert an asset to cash quickly and demonstrates the organisation's ability to handle working capital. Lastly, economic and physical efficiency is essential and should be examined. Low profitability is commonly caused by inefficient usage of resources in a business. Solvency is defined as having enough assets in one business to cover all of the business's liabilities. When business equity becomes negative, it is said to be insolvent. The degree of solvency in business is measured by the relationship between the assets, liabilities and equity at a given point in time. By subtracting liabilities from assets, the amount of equity in the business can be calculated. The larger the amount of equity, the better the business (Battles & Robert C. Thompson, 2000).

Hence, the Utility Theory concept aims at assessing the advantages and disadvantages of decision making. Rational decision making maximises the utility, which is made by an individual for their farm performance (Edwards, 1954). Figure 2.1 demonstrates a procedure to diagnose a business problem of a farm.

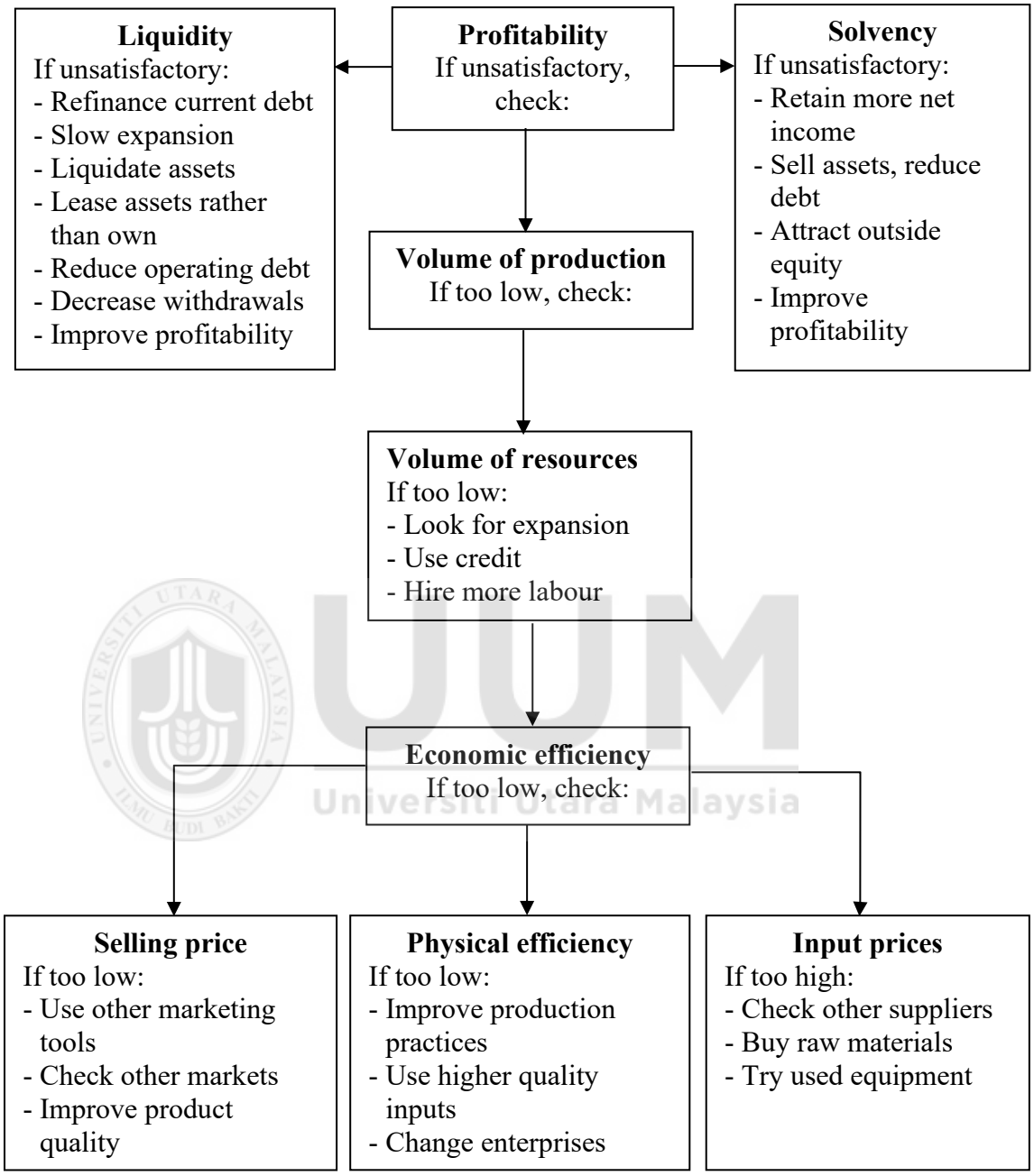


Figure 2.1
Procedure for diagnosing a farm business problem
Adapted from Kay et al. (2016)

2.4 The Use of Utility Theory

Based on previous studies, this study measured utility regarding the advantages and benefits of adopting innovation. It includes the profitability and efficiency of innovation in beef cattle farming, involving the business's total revenue, total cost, profit, solvency, and liquidity. When farmers accept and adopt innovation in cattle farming, they have decided to maximise farm cost for farm performance. Identifying the farm's financial report can conclude their business performance before and after adopting innovation in their farming activities. If the utility to adopt an innovation is higher than non-adoption, the farmer will be ready to adopt the innovation in cattle farming.

2.5 Technology Acceptance Model

The introduction of the Technology Acceptance Model (TAM) in 1986 was the adaptation from the Theory of Reasoned Action (TRA). After that, adjustments are done to suit the context of users' acceptance of the information systems (F. D. Davis et al., 1989). According to this model, anyone who employed the technology is directly or indirectly affected by behavioural intentions, attitude, perceived usefulness and perceived ease of use of the technology.

Furthermore, Teo (2011) mentioned that researchers in technology acceptance studies have become more interested in understanding factors that influence technological capabilities in various areas of study. Meanwhile, according to Chang et al. (2011), studies showed that cognitive approaches, behaviours and behavioural intentions

affect individuals in deciding on current technology. On the other hand, a cross-cultural study conducted in Australia and Thailand found that perceived ease of use significantly impacted the adoption of mobile banking in the selected area in Thailand (Mortimer et al., 2015). Phonthanukitithaworn et al. (2015) mentioned that the community in Thailand is aware of mobile service payment benefits or m-payment. This phenomenon was proven as most people believed that using m-payment services will further enhance payment transactions' efficiency. In other words, TAM has been extensively used by various scholars in different fields around the world.

Based on Figure 2.2, perceived usefulness and perceived ease of use significantly impacted attitude towards using technology, which will make the users use technology or system. Moreover, the definition of perceived usefulness and perceived ease of use are explained as follow.

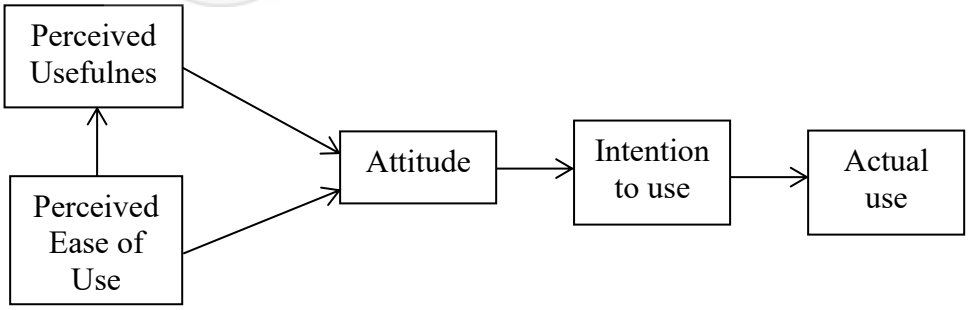


Figure 2.2
Technology Acceptance Model
Source: Davis et al. (1989)

2.5.1 Perceived Ease of Use

Perceived ease of use is one of the variables in TAM, which explained by Davis et al. (1989) as a system that is easy to use and free from difficulties. Users will feel freedom by using it, and it is free from physical or mental effort (Davis, 1989). An individual will tend to employ technology when it is flexible and straightforward to learn. Besides, users can focus and increase their performance by adopting a simple technology to their work or businesses.

2.5.2 Perceived Usefulness

The next variable of TAM is perceived usefulness. It is understood as an individual who believes that employing particular innovation or technology would enhance the work's performance (Davis, 1989). Hence, when users have a high perception of the benefit of that system, more users will employ it in the future. Furthermore, as mentioned by Simon and Shallone (2013), perceived usefulness is crucial in deciding innovation adoption. This variable is necessary to predict whether or not a system can help the users' daily routine.

2.6 The Use of Technology Acceptance Model

Based on the overall discussions about technology acceptance in the previous studies, it is understood that perceived ease of use of the system or innovation is easy to use while perceived usefulness is the benefit of employing the system. Hence, these two

variables can measure the effortlessness and effectiveness of the innovation by the farmers.

Referring to a study done among the entrepreneurs in the east-coast region of Peninsular Malaysia, it was found that 76.7% of the entrepreneurs had a low acceptance level towards technology. The constraints that led to this situation were a lack of access to financial sources and limited information regarding the current technologies on fish cracker processing (Mohamad Termezai et al., 2017). Furthermore, the study also employed perceived ease of use and perceived usefulness as the independent variables to measure the relationship towards accepting the technology. The result found that perceived ease of use had a significant positive low relationship with ($r=0.329$, $p<0.001$) where the respondents see the technology as easy to employ and does not require much physical effort. Hence, the fish cracker's entrepreneurs will consider using it to enhance their business performance (Mohamad Termezai, 2019). The same thing happened to the perceived usefulness, where the result showed a significant positive low relationship towards the acceptance of technology ($r = 0.455$, $p<0.01$). The respondents have mentioned that using fish cracker processing technology can improve their job performance and have a bright future in their business performance (Mohamad Termezai, 2019).

There are different results found when employing TAM in various studies as it depends on the population and the location of the study. As for this study, cattle farming management was measured by adopting innovations such as vaccination, feeding system and breeding technique. If cattle farmers are comfortable and believe that

innovation would increase their farm performance, they would adopt the innovation in their farms.

2.7 Diffusion of Innovation Theory

Diffusion of Innovation Theory is known among researchers worldwide and is frequently used by researchers in innovation studies. Rogers (1995) stated that many studies are investigating the behaviour of several adopter categories, but limited research is conducted on how innovation impacts the rate of adoption. Thus, any research studies regarding the impact of innovation can be a valuable effort to identify people's reactions to innovation.

The perceived attributes of innovation is an elaboration on the rate of adoption of an innovation. The attributes are relative advantage, compatibility, complexity, trialability and observability (Rogers, 1983). Meanwhile, other variables, namely type of innovation-decision, communication channels, social system and extension workers' effort to deliver the innovation, are referred to in Figure 2.3.

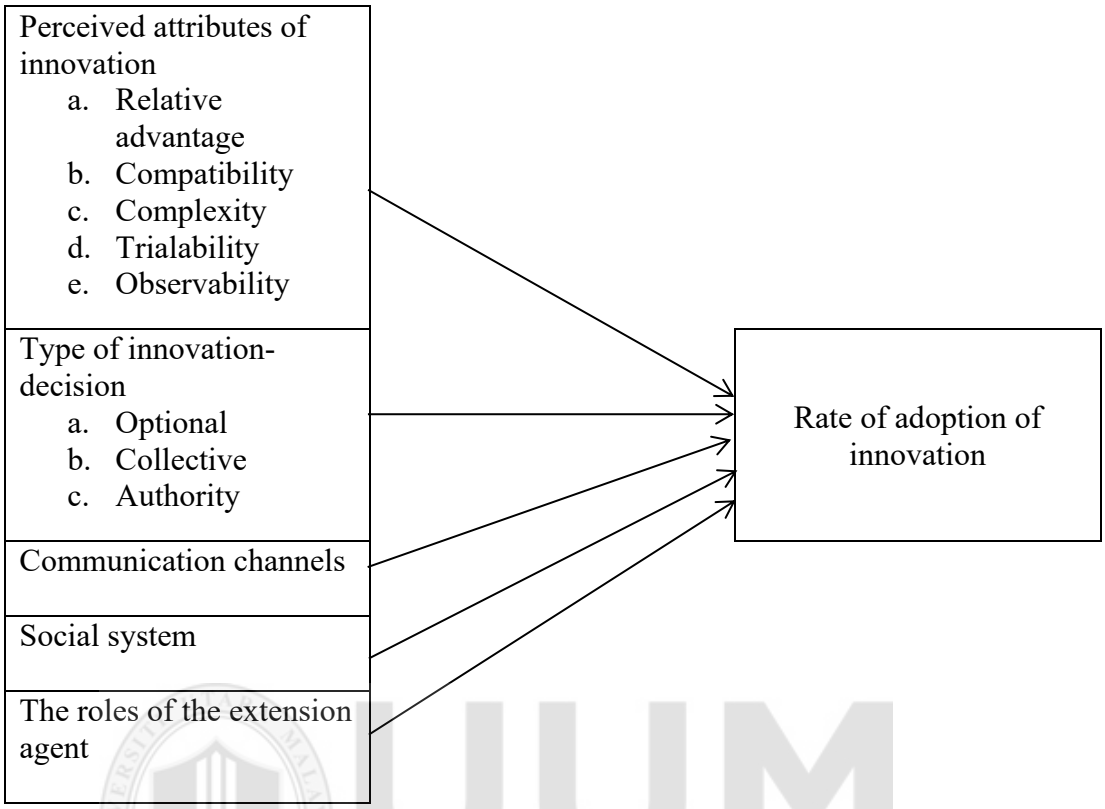


Figure 2.3
Determining variables in Diffusion of Innovation Theory
Source: Rogers (1983)

2.7.1 Perceived Attributes of Innovation

Perceived attributes of innovation are a crucial explanation of the adoption rate of innovation—the attributes are relative advantage, compatibility, complexity, trialability and observability. Personal and optional innovation are usually adopted faster than an organisation or collective innovation. However, according to Sahin (2006), relative advantage is the most potent variable in determining the rate of innovation adoption, which has been tested by many researchers.

a. *Relative advantage*

Relative advantage is understood as how far the innovation is more advanced than the previous ideas. Relative advantage indicates economic growth, status in a social system, among other benefits. The essence of innovation determines certain relative advantages, such as economics and social, which are essential to adopters. On the other hand, most innovators, early adopters and an early majority are extra motivated to adopt innovation. Still, the late majority and laggards view innovation as less important to them.

Furthermore, there are two types of innovation: preventive and incremental (non-preventive) innovation (Rogers, 1995). Preventive innovation is a new idea currently adopted and practised by an individual to reduce the likelihood of an unwanted event occurring in the future (Rogers, 2003). Besides, preventive innovation is generally adopted at a slow pace; so, their relative advantage is highly undetermined. Meanwhile, incremental innovation delivers excellent results in a brief period. Thus, by increasing the rate of adoption of innovation and ensuring that the relative advantage is more efficient than previous, the respective organisations' incentives can be reliable in supporting people in a social system (Sahin, 2006).

b. *Compatibility*

Compatibility is the extent to which innovation is suitable for current values, previous experiences and prospective adopters' needs (Rogers, 1995). However, if the innovation is consistent with people's requirements, uncertainty decreases, and the

innovation acceptance rate boosts. Hence, such compatibility gives meaning to the new ideas noticed as familiar among the individuals (Rogers, 1995).

c. *Complexity*

The complexity of innovation is seen when innovation is somewhat hard to implement (Rogers, 1995), and it is negatively associated with the adoption rate. Thus, the disproportionate complexity in innovation is an obstacle to the adoption rate (Rogers, 1995).

d. *Trialability*

Trialability is the degree to which innovation can be experimented with restricted funds, according to Rogers (2003). Also, there is a positive correlation between trialability and the adoption rate. The more innovation is tried, the faster the adoption. Furthermore, reinvention may also occur during innovation attempts (Rogers, 1995). Then, the potential adopters can modify the innovation, while the improvement of reinvention can make the use of faster innovation (Sahin, 2006).

e. *Observability*

The last feature of innovation is observation. Rogers (2003) defines observability as the extent to which others can see innovation results. Innovation's results are easily

noted and conveyed to others, but some are hard to observe and explain (Rogers, 1995). According to Paricot (1997), observation of the modelling partners is a major motivating factor in technology recognition and implementation.

2.8 Key Components of Diffusion of Innovation

There are four key components of diffusion of innovation: innovation, communication channels, time and social system. According to Sahin (2006), innovation has been invented long ago, but it can be innovative if it is still seen as new. New features in adoption are more relevant to the three steps: knowledge, persuasion and decision. Moreover, uncertainty is a barrier to adopting innovation due to other unforeseen circumstances, leading to difficulty. As Rogers (2003) mentioned, this phenomenon usually occurs among people in a social system, making an individual accept or reject an innovation.

Next, the communication channel is the second component in the process of diffusing innovation. It is a method in which individuals generate and share data with other people to achieve mutual comprehension (Rogers, 2003). This communication is defined as an individual or organisation that derives a message and occurs between sources through channels. Rogers (2003) also stated that a channel could understand information delivered to the receiver from the trusted sources.

Additionally, time is also a key component of the diffusion of innovation. Unfortunately, Rogers (2003) stated that the time aspect has been neglected in many

studies regarding human behaviour. Moreover, the time component includes the innovation-diffusion process, categorisation of adopters and adoption rate.

Lastly, the social system is a collection of units that work together to solve issues and attain common objectives (Rogers, 2003). Diffusion of Innovation is commonly taking place in the local society, and therefore, the social structure of a social system can be affected. Indeed, Rogers (2003) also claimed that the nature of the social system impacts people's innovativeness, which is the primary foundation for adopters to be categorised.

2.9 Model of Five Stages in Innovation Decision Process

A five-stage model in the innovation decision-making process has been developed by Rogers (2003). It explains how people gain knowledge through the communication channel and decide whether or not to accept something. Figure 2.4 shows that communication channels' flow starts with knowledge, followed by persuasion, decision, implementation and confirmation.

At the first stage, an individual will learn about innovation and search for the innovation data. The critical questions such as “what?” “how?” and “why?” are common in the knowledge phase. Rogers (2003) stated that an individual also undertakes to determine what kind of innovation is, how and why it works for society. Not only that, the questions further form three types of knowledge, namely; (1) awareness-knowledge, (2) how-to-knowledge and (3) principles-knowledge. The awareness-knowledge is about the knowledge of the innovation’s existence. This kind

of knowledge would be able to motivate individuals to learn about innovation and adopt it. Besides, it is possible to encourage a person to try for the other two types of knowledge. Next, the how-to-knowledge is full of information on how to employ an innovation accurately.

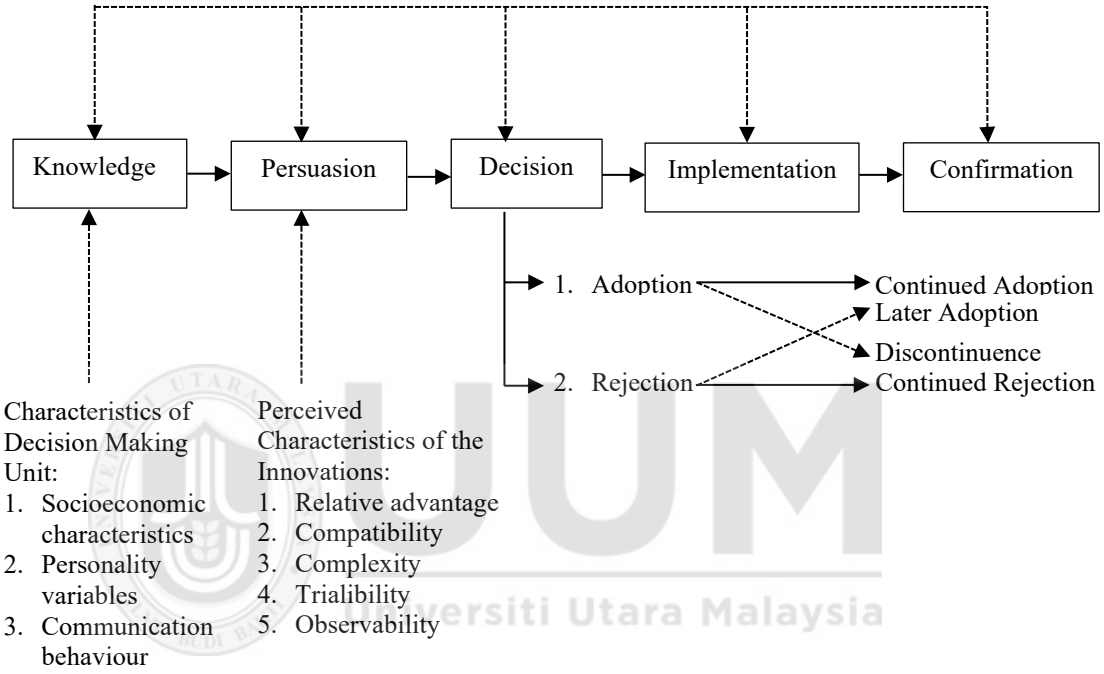


Figure 2.4
Five stages of the innovation-decision process in the Diffusion of Innovation Theory
Source: Rogers (2003)

Moreover, to improve the possibility of adopting innovation, people must have a sufficient level of how-to-knowledge before adopting this innovation. Hence, this knowledge becomes essential for comparatively sophisticated innovation. Finally, the last type of knowledge is principles-knowledge. This knowledge describes the functioning principles of how and why an innovation works at a particular phase. The

adoption of innovation can function without principles-knowledge, but the wrong application may cause its discontinuation.

The next stage is persuasion. This step occurs when an individual has a negative or positive attitude toward innovation, but it does not directly decide to adopt or reject an innovation (Rogers, 2003). Individuals will shape their attitudes after they are informed about innovation. Thus, the level of persuasion comes with the level of knowledge in the process of innovation decisions. Furthermore, Rogers (2003) stated that the level of knowledge is more cognitive (or knowing) centred, while the level of persuasion is more influential (or feeling) centred. Therefore, the individual involved will be more sensitive to innovation at the persuasion level.

Then, the third stage is the decision stage. At this stage, an individual chooses to adopt or reject the innovation. Referring to Rogers (2003), adoption is the full use of an innovation as the best available option for society. Still, the rejection can be defined as did not adopt an innovation. If an offer of innovation is for trial, it will usually make speedy adoption as most individuals are interested in trying the innovation in their situation and will later decide either to adopt or not (Sahin, 2006).

Nevertheless, there is a possibility of rejection in every stage of the innovation-decision process. Rogers (2003) stated that it has two types of rejection: active rejection and passive rejection. In an active rejection situation, an individual tried an innovation and considered adopting it, but a few days or months later, he or she decides to reject it. Meanwhile in a passive rejection (or non-adoption) position, the individual has rejected the innovation.

The implementation stage is the fourth stage in the innovation-decision process. At this stage, innovation is put into practice. However, uncertainty about the result of the innovation would still be a problem at this stage. Hence, the individual may need technical support from extension agents and others to lessen the uncertainty about the consequences of an innovation. On the other hand, reinvention also frequently happens at the implementation stage, which later leads to modifying an innovation by a user in the process of its adoption and implementation (Rogers, 2003). Besides, there is a difference between invention and innovation. An invention is a process of discovering a new idea involving creating the current technology, while an innovation uses an existing idea (Rogers, 2003). Indeed, if more reinvention takes place, the innovation would be more rapidly adopted and becomes institutionalised.

The last stage of the innovation-decision process is confirmation. At this stage, once an individual has made an innovation decision, they will get support from somebody for their decision (Sahin, 2006). However, the decision can also be reversed if the individual faces particular messages on innovation conflicts (Rogers, 2003). Nevertheless, the individual will avoid these messages and look for supportive messages to confirm their decision. Thus, attitude becomes more critical at the confirmation stage. It depends on the support obtained from outside parties to adopt the innovation and the individual's attitude. Hence, later adoption or discontinuance takes place at this stage. Discontinuance may happen at this stage in two ways. First, the individual rejects the innovation because they planned to adopt a better innovation. This kind of discontinuance decision is called replacement discontinuance. Next is disenchantment discontinuance; the individual rejects the innovation due to the failure

to satisfy its performance. Meanwhile, another reason for this discontinuance decision could be that the innovation does not meet the individual's needs. So, it failed to provide a perceived relative advantage as the first attribute of innovation and could affect the adoption rate.

2.10 The Use of Diffusion of Innovation Theory

The primary reference in this study employed the Diffusion of Innovation Theory by Rogers (1983). Based on the literature, insufficient studies have been done to investigate the adoption rate of innovation among individuals (Rogers, 1995). This study adopted a theoretical framework by employing several variables from the Diffusion of Innovation Theory. First, the socio-demographic profile included discovering the respondents' background, such as age, education, years of experience in beef cattle farming, farm distance to veterinary extension centres and off-farm employment. Goswami et al. (2012) as well as Paul et al. (2017) employed these variables as the respondents' socio-demographic profile to identify factors that influence the adoption of innovation. Secondly, access to information was also selected as one of the variables in this study since it is crucial in delivering and transferring knowledge about a system (Yao et al., 2018). The following variable was the influence of the social system such as culture, practice and trust. This variable is crucial since farmers have frequent contact with farmers' community and family members; besides, it may influence them towards the current farming practices (Yao et al., 2018). Lastly, extension services such as government extension services and farmer-to-farmers extension services also played a significant role in this research. Davis et al. (2012) and Yao et al. (2018) mentioned that introducing the latest farming

method by the extension agents had influenced farmers to implement it onto their farm or vice versa.

2.11 Empirical Studies on the Adoption of Innovation

This section discusses previous studies on innovation adoption in beef cattle farming and also the related studies. The discussion explains the theories, methodology and variables employed by the researchers to identify several factors that influence farmers to adopt innovation in agriculture, especially in beef cattle farming.

In a study by Baba et al. (2019), several factors had affected the acceptance of agricultural waste as cattle feed among farmers in Maros Regency, Indonesia. Ninety-six farmers from various agricultural backgrounds were involved in the study, including rice, corn and cattle productions. The binary logistic regression model indicated (0) as no adoption and (1) as adoption on the utilization of straw as feed. Six out of nine variables measured had influenced the adoption of agricultural by-products as cattle feed. These factors included work perception, good relationship with extension workers, cultivated rice area, number of cattle, subjective norm and difficulty in processing cattle feed. Farmers' motivation to adopt innovation has increased as they spent their free time on farming activities (Baba et al., 2019). Besides, a good relationship with extension workers had also influenced farmers to adopt innovation as they had adequate information from extension workers. It is essential and a key driver of technology utilisation in Maros (Baba et al., 2019). These findings are also in line with a study done by Rogers (2003).

Farmers who have more cattle have a higher tendency to make the rice and corn straw as feed. This situation was due to the increasing demand for feed as the rising number of cattle (Baba et al., 2019). Adopting agricultural by-products as cattle feed has been associated with difficulties in the management and processing part. Labour is crucial to process the corn straw, which has become the inhibiting factor in utilising agricultural by-products as cattle feed (Mudzengi et al., 2014). However, age, experience, number of family labour and education level appeared insignificant towards adopting agricultural by-products as cattle feed.

On the other hand, Paul et al. (2017) conducted a study among farmers in Caribbean Island regarding compost adoption. The study explored the determinants of farmers' in adopting compost and stratified sampling employed. About 520 farmers were involved with different agricultural backgrounds, such as sugarcane, banana, tuber, vegetable and livestock. The study consisted of three (3) categories of independent variables: farmer's human capital or socio-economic, farm resources as well as the type of farming and production system adapted from Utility Theory and Diffusion of Innovation Theory. The socio-economic part comprised age, education, farmer's experience and information access from the extension office. Meanwhile, farm resources such as farm size appeared insignificant towards adopting compost use. The dependent variable is a dichotomous manner describing (0) as no adoption and (1) as adoption of compost amendment on the farm. Logistic regression analysis has been used to identify factors contributing towards adoption in compost use.

The result of the study found that age has a significant and negative effect on compost adoption. This finding aligns with Folefack (2015) and Sotamenou and Parrot (2013)

stating that as the farmer gets older by their age, it is more difficult for them to adopt the innovation. Besides, farmers' experience was also correlated and significant towards adopting compost use. The experienced farmers were reluctant to change into new farming practices in several European countries (Long et al., 2016). The other factors such as education level, membership in farmers' association and information access also significantly influenced the adoption of innovation. The results obtained are similar to those presented by Ajewole (2010) and Folefack (2015), where educated farmers with a better understanding and trained farmers enjoyed more benefits than those without. Good contact with extension centres and farmers' organisations also will ease the farmers as the information is well-disseminate (Folefack, 2015). Family labour also had a significant effect on the adoption of compost use. As the number of households involved increases, the farm activities should also increase the adoption by reducing manual applications, specifically on a small farm (Paul et al., 2017). Two variables found were not significant towards compost adoption, namely farm size and off-farm employment. The farm size variable was considered a relative measure specific to the socio-economic context and might not be essential at all generalisation (Sotamenou & Parrot, 2013). However, Ajewole (2010) stated that farm size had a negative relationship with compost adoption due to the barriers that occurred on manual application. Next, the non-significant finding of off-farm employment towards compost adoption is in line with Folefack (2015) that farmers with off-farm activities in Cameroon were not interested in adopting compost than those who were fully committed to agricultural work. Income levels and the price sold for compost were the essential variables for economic factors. Farmers' perceptions of innovations such as total working hours and farm management were also considered as a vital element of measurement in a study.

Besides, Rathod et al. (2017) discovered factors affecting the adoption of AI among 360 farmers in four states of North India. Multistage random sampling and snowball methods were employed to get the respondents and Diffusion of Innovation Theory as the base of the study. The multinomial logit model was employed, and the dependent variable describes three (3) discrete values – (0) as no adoption; (1) as partially adopted AI; and (2) as fully adopted AI to identify the most critical decision and the degree of adoption. From the study, the multinomial logit model depicted the Chi-square value of 113.97, indicating that the model was highly significant ($p < .000$) and two significant variables had influenced partial and full adoption of AI, namely education and distance to the veterinary extension centre. Adeogun et al. (2008) and Odendo et al. (2009) also reported that education was positive and significantly impacted the adoption of current innovation. Furthermore, the increase in distance to the veterinary extension centre also tends to increase farmers' tendency to move towards the non-adoption of AI (Rathod et al., 2017).

The herd size and scientific orientation also had significantly influenced the full adoption of AI. As the cattle scale increases, the adoption of innovation increased (Rathod et al., 2017). The addition of a significant number of cattle will make the farmers consider implementing innovations for their farms. The scientific orientation, such as the excellent conception rate of AI, the availability of the resources for performing AI and affordable charges for AI services, have increased the innovation rate among cattle farmers (Rathod et al., 2017). Hence, the mentioned variables played a vital role to determine the full adoption of technology among farmers. However,

several factors were insignificant towards partial or full adoption of AI, such as farmers' age, farm size, information-seeking behaviour and family size.

A subsequent study was conducted by Wahyudi (2017) on the factors affecting biogas technology adoption in cattle farming among farmers in Pati, Indonesia. A cross-sectional survey was employed to investigate the differences between households with and without biogas digester. Biogas digester was designed to process the cattle's waste and turn it into biogas sources with a specific measurement suited to the study location. In the study, Slovin's formula was used to determine the sampling size, and 132 respondents with biogas adopters and non-adopters were interviewed using the structured questionnaire. Besides, an in-depth interview was also conducted among the selected farmers to investigate the performance of installed biogas and biogas digesters' management. Based on the findings, education level, income and herd size influenced the adoption of biogas technology. The possession of Javanese culture believed that those with higher income and a good education background had a high social status. Hence, farmers with higher income and a good relationship with extension agents would help them obtain information regarding biogas technology (Wahyudi, 2017). The income level and the herd size had also influenced cattle farmers to adopt innovation as they were willing to pay and were encouraged to participate in the biogas project. Unfortunately, age, family size and experience were insignificant in adopting biogas technology (Wahyudi, 2017).

On the other hand, Baba et al. (2014) conducted a study on adopting intensive rearing techniques among 90 respondents in Wajo Regency, Indonesia. Intensive rearing is formerly known as the proper housing system, feeding, reproduction and health

management. The Utility Theory, Diffusion of Innovation Theory and Technology Acceptance Model was implemented as the foundation of the study, while multiple linear regression was employed to analyse factors affecting intensive rearing adoption. The dependent variable is the adoption rate of intensive rearing, which is measured using five indicators: cattle housing system, feeding technology, reproduction management, disease control, and waste management. The study found that relative advantage, subjective norm and behavioural control were significant in adopting intensive rearing. The economic benefit variable or relative advantage was identified as the key in adopting technologies among farmers (D'Emden et al., 2008). Ease in the feeding process, control reproduction, reduced use of labour, theft issues and ease in health control were the examples of relative advantages in beef cattle farming.

Furthermore, the social pressure among the committee of farmers also had influenced them to adopt innovation, especially if they hold a good position in the farmers' association. These findings are aligned with Manner and Gowdy (2010) that every farmer is trying their best to have a good social status in their community. Moreover, a farmer will adopt intensive rearing to control future consequences since adopting intensive rearing requires extra knowledge, skills and cost (Burton, 2004; Mzoughi, 2014). The other five independent variables; contact with extension agent, attitude, age, farm size, and family size, were insignificant in adopting intensive rearing.

On the other hand, Young et al. (2014) conducted a study in Cambodia on adopting best practice health and husbandry interventions. Their cattle production has suffered from transboundary animal diseases (TAD) such as foot-and-mouth disease (FMD), haemorrhagic septicaemia (HS), plus poor nutrition, reproduction and marketing

knowledge. The project took about five years, from 2007 to 2012, in six villages at Kandal, Takeo and Kampong Cham province. The farmers were then categorised into 'high intervention' (HI) and 'low intervention' (LI) villages. Farmers from three HI villages received a participatory extension programme including FMD and HS vaccination, forage development and husbandry training, while farmers from the other three LI villages had only received vaccinations for their cattle. At the same time, another study was conducted in 2012 among 120 farmers by the same researcher, revealing that farmers' knowledge in the HI villages exceeded LI villages regarding biosecurity, nutrition, internal parasites and reproduction. Farmers at HI villages implemented biosecurity practices at their farm, vaccinated FMD and HS for their cattle, grew their forages, separated the sick cattle and distributed awareness on the benefits of building fattening pens.

The evaluation of project impacts on livelihoods was facilitated by comparing these two groups. The HI farmers had planted the forages and saved up to two hours per day for men, women and children, which can expand the enterprise, grab secondary employment and fulfil children's schooling. Logistic regression analysis found that farmers from the HI group had a significant increase in their annual household income. Hence, it has also improved farmers' attitude, knowledge and practice in cattle health, leading to a more outstanding production and improved farmers' livelihood.

Furthermore, in the same research project, Ashley et al. (2018) examined the impacts and financial condition of 120 farmers on adopting forage technology. The farmers were divided into three categories; adopter at HI sites, non-adopter at HI sites and non-adopter at LI sites. The collected and analysed data included cattle-feeding practices,

household labour demands of sourcing feed for cattle and forage-plot establishment's input costs. The result reported significant findings on reducing the hours spent for sourcing feed and reduced the involvement of adopter households, including women and children, compared to non-adopter households.

Meanwhile, the average total cost of inputs on forage-plot establishment per 100 m^2 was ranged from United States Dollar (USD) 1.40 to 16.88, which is an average of about USD 5.60. The seed costs were estimated at USD 0.50 per 100 m^2 for a total input cost of USD 6.10 per 100 m^2. Partial budget analysis was used to compare the value of forage feeding of the following two scenarios over a 6-month wet-season period: (1) forage-plot establishment and forage feeding across the herd; and (2) forage-plot establishment and target feeding (fattening) of one animal. A net profit of USD 139.01 for Scenario 1 and USD 152.94 for Scenario 2 and the Monte Carlo simulation indicated similar financial outcomes for both scenarios, namely USD 169.09 and USD 172.33, respectively. A Monte Carlo simulation is a model used to predict the probability of different outcomes when random variables are intervention. The findings are almost similar to that by Young et al. (2014) and forage technology was believed as one of the strategies to improve the standard of living among smallholder cattle farmers in Cambodia.

Roessali et al. (2011) also studied factors influencing farmers' decisions in adopting innovation to increase the beef cattle business scale. The study took place in Central Java Province, Indonesia, and 196 respondents were randomly selected as the respondents of the study. Utility Theory and Diffusion of Innovation Theory were used as the foundation, and probit model analysis was employed to examine the influencing

factors. The binary dependent variable represents (1) as farmers decide to expand the production, and (0) is otherwise. Herd size, education level and income were significant with a negative relationship to increase the production. As the business scale is increasing, farmers will not increase the herd size due to insufficient capacity and feed availability (Roessali et al., 2011). Moreover, education level has also shown a negative relationship to increase the business scale. This situation was because most educated farmers reduce their working time allocated to the cattle business but choose to work in the non-agricultural sector with prestigious economic status (Hartono et al., 2005). Therefore, they do not have enough time to focus on rearing numerous beef cattle. Meanwhile, the farmers' income was also negatively correlated, indicating that as income is getting higher, it leads to a higher tendency of a farmer to reduce the working time and adopt innovation to increase the business scale (Roessali et al., 2011). Family labour was the only variable found as significant with a positive relationship. This situation explains that the more family members are able to work at the farm, the more they are encouraged to increase their business scale, adopt innovation and improve beef cattle management (Roessali et al., 2011). However, age and farm size were not significant in the study and did not influence a farmer to adopt innovation to increase the business scale.

Hence, the empirical studies discussed above are summarised in Table 2.1 and Table 2.2 as follow:

Table 2.1
Factors affecting the adoption of innovation

Independent variables	**Result**	**Author(s)**
Age	Significant, p<0.1	Paul et al. (2017)
	Not significant	Baba et al. (2019); Rathod et al. (2017); Wahyudi (2017); Baba et al. (2014) Roessali et al. (2011)
Education	Significant, p<0.01	Paul et al. (2017)
	Significant, p<0.05	Rathod et al. (2017); Wahyudi (2017); Roessali et al. (2011)
	Not significant	Baba et al. (2019)
Experience	Significant, p<0.05	Paul et al. (2017)
	Not significant	Baba et al. (2019); Wahyudi (2017)
Part-time farmer/ off-farm employment	Not significant	Paul et al. (2017)
Farm size	Significant, p<0.01	Baba et al. (2019)
	Not significant	Baba et al. (2014); Paul et al. (2017); Rathod et al. (2017); Roessali et al. (2011)
Income	Significant, p<0.05	Wahyudi (2017)
	Significant, p<0.1	Roessali et al. (2011)
Herd size	Significant, p<0.01	Baba et al. (2019)
	Significant	Rathod et al. (2017)
	Significant, p<0.05	Wahyudi (2017)
	Significant, p<0.1	Roessali et al. (2011)
Distance to extension centre	Significant, p<0.05	Rathod et al. (2017)
Contact with an extension worker	Significant, p<0.01	Baba et al. (2019)
	Not significant	Baba et al. (2014)
Farmer-to-farmer extension/ farmers' association	Significant, p<0.01	Baba et al. (2019); Paul et al. (2017)
	Significant, p<0.05	Baba et al. (2014)
Access to information	Significant, p<0.01	Paul et al. (2017)
	Not significant	Rathod et al. (2017)

Table 2.2
Summary of the variables

Author(s)	Age	Education	Experience	Off-farm employment	Farm size	Income	Distance	Extension service	Farmer-to-farmer	Access to info	Herd size
Baba et al. (2019)	X	X	X		√			√	√		√
Paul et al. (2017)	√	√	√	X	X				√	√	
Rathod et al. (2017)	X	√			X		√			X	√
Wahyudi (2017)	X	√	X			√					√
Baba et al. (2014)	X				X			X	√		
Roessali et al. (2011)	X	√			X	√					√

Indicator:
√ Significant
X Not significant
□ Not measured

2.12 Review on Methodology

There are various methods been implemented by scholars to investigate factors and the economic evaluation on adopting innovation. In Maros District, South Sulawesi, Indonesia, Baba et al. (2019) conducted their research on adopting agricultural by-products as feed. Maros was chosen as it is the most suitable site for the survey and is a centre for paddy, corn, and Bali beef cattle production in Eastern Indonesia. Data collection was run by the trained enumerators using questionnaires from March to

December 2015. The researchers have employed quota sampling, and 96 smallholder beef farmers were selected as the respondents of this study. The dependent variables, adoption and utilization of crop-residues technology, were measured using a dichotomous model where (1) meant was adopted while (0) meant was not adopted. Logistic regression model was employed to determine factors influencing the adoption of crop residues as a feed.

On the other hand, a study conducted by Paul et al. (2017) on the adoption of compost use in Caribbean Island involves 520 farmers from different backgrounds, either crops or livestock. Data were collected from September to December 2014 and was carried out through face-to-face interviews by three trained enumerators. The respondents were selected using stratified random sampling covering the entire territory, with 279 were located in Grande-Terre and 241 in Basse-Terre. A structured questionnaire comprised of two sections was used as the instrument of this study. The first section is about the reasons for using and not using composts, while the second section describes the farmer's socio-economic profile, the structure of their farms and what type of farming system they have employed in terms of crops and livestock. The variables collected from the second section were used to model compost adoption and are described in detail. The dependent variable, adoption of compost amendment on-farm were measured using a dichotomous model where (1) meant was adopted while (0) meant was not adopted. Logistic regression model was used to identify factors towards the adoption of compost use.

Furthermore, a study by Wahyudi (2017) on adopting biogas technology among cattle farmers in Pati regency, Indonesia, was conducted from March to October 2016. More

than 1.2 million populations in this area make the agriculture sector their primary source of income, followed by the trading sector. A quantitative approach with cross-sectional survey was employed as the research design of this study. The data collection process was conducted among 132 sample households consisting of 66 biogas adopters and 66 non-biogas adopters using structured questionnaires as the primary tool for data collection. The first section of the questionnaire provided data regarding the socio-economic characteristic, while the second part was about the reasons to adopt or not to adopt the technology among the respondents. The questionnaires have also gone through the review process and been presented to a cattle farmer, a representative of local NGO, and a researcher from the Development Planning Agency of Pati regency to determine the suitability of the questions in collecting the required data. After that, the data from respondents is analyzed with descriptive statistics. Direct observations and interviews collected the other primary data through a qualitative approach. Direct observation is an appropriate technique to observe the performance of biogas installed and the management of biogas digesters. Interviews have also been conducted to explain the motivation to adopt or not to adopt the technology and its status.

A study by Young et al. (2014) took place in Cambodia on adoption of BPHH by smallholder cattle farmers. On this project, village selection criteria included a minimum of 250 head of cattle, year-round road access, and village authorities' willingness to participate in the initiative. Initially, 645 households from the six villages were enrolled, totalling 1,519 animals. Through 'best practise' interventions, the project worked with smallholder farmers to improve cattle health and output. Workshops lasted from one to four days, with topics addressed. District and provincial veterinary officers and project employees received additional technical training in

biosecurity, disease investigation, control, and reporting. The questionnaire was designed in January 2012 and consisted of 67 questions. Questions enclose knowledge, attitudes, practice and socio-economic aspects of BPHH project impacts on smallholder cattle production. Marketing knowledge and practices were assessed by asking farmers whether they knew the current market price of their cattle. Questions were kept straightforward to minimize wordiness and any reporting errors. In order to participate in the questionnaire, one hundred twenty farmers were selected from the six project-area villages. All interviews were conducted in their local dialects, Khmer, and all responses were recorded onto a predesigned survey and answer sheet. The results were then translated into English and cumulative in a Microsoft Excel 2010 database.

Hence, based on all methods discussed, the logistic regression model using ordinal logit regression has been chosen to determine the factors influencing adoption of innovation in beef cattle farming. Descriptive statistics is employed to identify the profitability and efficiency of the farmers.

2.13 Research Gap

Based on the previous literature review, there are insufficient studies conducted on the economic implications specifically in farm's financial performance, including the profits earned, cost of production, liquidity, and solvency for before and after adopting innovation in beef cattle farming. For example, the machine named OTOSIL to produce high-quality silage has been proved to decrease the production cost and increase feed production. By using this machine, farmers can reduce 22% of

production cost and increase 12% of silage quality, hence can overcome the issues of insufficient feed during drought or flood season. At the same time, it also shows the critical role of farmer-to-farmer extension in farming activity. It is considered appropriate to put it in a framework to test in the Malaysian context. In addition, access to information is another significant variable in measuring the accessibility of a farmer to get the skills and knowledge transfer. This study also employed ordinal logit regression as it is more appropriate to measure farmers' adoption of innovation.

2.14 Summary

Related theories, topics and variables in the previous studies have been discussed, including the socio-economics factor and the institutional factors that contribute towards adopting innovation in beef cattle farming (Baba et al., 2014, 2019; Paul et al., 2017; Rathod et al., 2017; Roessali et al., 2011; Wahyudi, 2017; Young et al., 2014). Utility Theory and Diffusion of Innovation Theory have been selected as the foundation of this study because these theories describe the characteristics of individuals or organizations to make a good decision. The quantitative and cross-sectional survey has been employed by most researchers in examining factors towards adopting innovation and the farms' financial performance. The data collection was conducted by trained enumerators using the structured questionnaire and face-to-face interview to ensure the data gathered is appropriate and meets the study's objective.

Besides, farm financial analysis is essential for a farmer to evaluate their farm's performance regarding the profitability and efficiency of a farm, as mentioned by Kay et al. (2016) in the Utility Theory. The impact of innovation before and after is crucial

for them to continue or stop adopting such innovations in beef cattle farming. Descriptive statistics is sufficient to analyse this type of objective. Furthermore, most of the previous studies employed logistic regression and probit models to examine factors influencing the adoption of innovation. Hair et al. (2014) agreed that logistic regression, also known as logit analysis, is a combination of multiple regression and multiple discriminant analysis. The logistic regression technique is also closely similar to multiple regression analysis as it has one or more independent variables used to predict a single dependent variable. Logit analysis is the most appropriate and accessible analysis to investigate the adoption of innovation where the results are either to adopt or not to adopt the innovation (Hair et al., 1998). However, there is a difference with numerous regression analyses since the dependent variable of logistic regression is nonmetric.

Hence, the logit model employed for this study consists of two categories of independent variables, namely (1) individual and farm factor; and (2) institution factor. The individual and farm factors include farmers' socio-economic background, such as age, experience, education level and herd size. Meanwhile, the institution factor comprises government extension, farmer-to-farmer extension and access to information. The farm's performance, including profit, solvency and liquidity, has also been discovered according to the region, rearing techniques and herd size. This analysis is essential to identify the effectiveness of such innovations employed by beef cattle farmers.

CHAPTER 3

METHODOLOGY

This chapter explains the procedures involved in this research. The information includes the research framework, hypothesis, questionnaire design and sampling procedure. Besides, the explanation also consists of the data preparation, such as a pilot study and examining the reliability and validity to ensure the respondents can understand the items used in the questionnaire. Lastly, the further explanation is on how the data collection has been conducted and the elaboration on the analysis to achieve the stated objectives.

3.1 Theoretical Framework

Generally, research methodology consists of several steps, including data collection and data analysis to get the findings and conclusion of the research (Tabachnick & Fidell, 2019). The suitable methodology will also ensure reliable and relevant research findings (Hussin et al., 2014). The theoretical framework must demonstrate the overall research and define each variable involved (Feder et al., 1985). Then, to create an understanding of the relationship among the dependent and independent variables. For this study, the theoretical development aims to answer the fourth objective: to examine the factors influencing innovation adoption in beef cattle farming.

Besides, the importance of farms' financial analysis has also been discussed, the profitability, efficiency as well as the liquidity and solvency. This part of the analysis is crucial to evaluate the farm's performance. The model of this study was based on the research conducted by Baba et al. (2019) as the foundation to examine the factors that influence the adoption of innovation among beef cattle farmers in Peninsular Malaysia. A study by Baba et al. (2019) has been chosen as the reference for the model development as it is the latest study in identifying the farmers' adoption in the innovation of cattle feed. However, not all variables in his study can be used because the variable selection must suit the current phenomenon of beef cattle farming in Malaysia and not focus on the particular innovation itself. Overall, the model of this study is modelled as 1) individual and farm factors (age, experience, education level, herd size); 2) institution factors (government extension, farmer-to-farmer extension, access to information). Figure 3.1 shows the suggested theoretical framework that explains the adoption of innovation influenced by the two categories of independent variables.

The theoretical framework of this study is suggested in Figure 3.1.

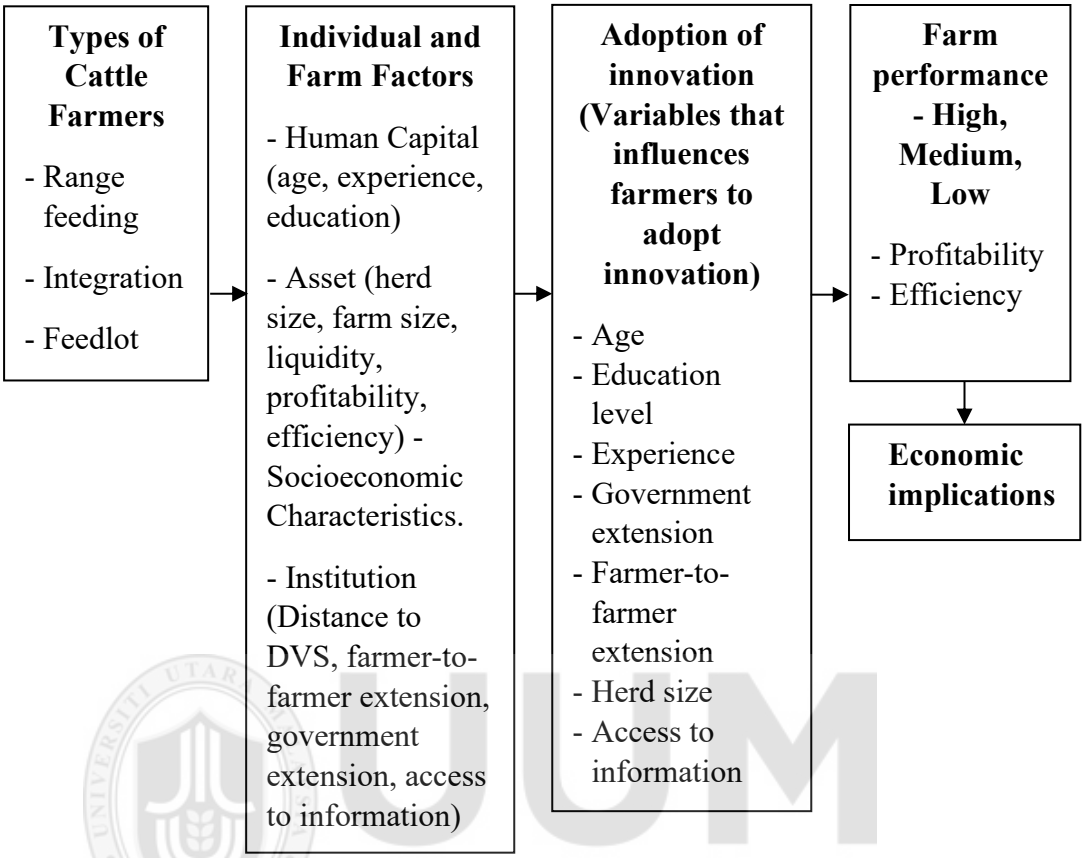


Figure 3.1
The theoretical framework of the study

3.2 Research Process

Adopting innovation by cattle farmers is assumed not random but strongly correlated with the background of farmers, such as age, experience, educational attainment and financial stability. Besides, social networks such as access to information, extension services either from the DVS or farmer-to-farmer extension have also become the contributing factors towards adopting innovation in beef cattle farming.

This study employed a quantitative research design with a cross-sectional survey to collect information about the farmers' background, beef cattle management as well as the process of transferring the skills and knowledge about innovation from the targeted respondents. The analysis was conducted using the appropriate statistical tools to generate the findings and conclusions. Hair et al. (2014) and Creswell (2003) mentioned that employing cross-sectional surveys is an excellent deal for social science studies.

This study also conducted a pilot study to check the time respondents took to answer all the questions, the questionnaire's suitability, and the instrument's validity and reliability (Hussin et al., 2014). Figure 3.2 below shows the research process of this study.

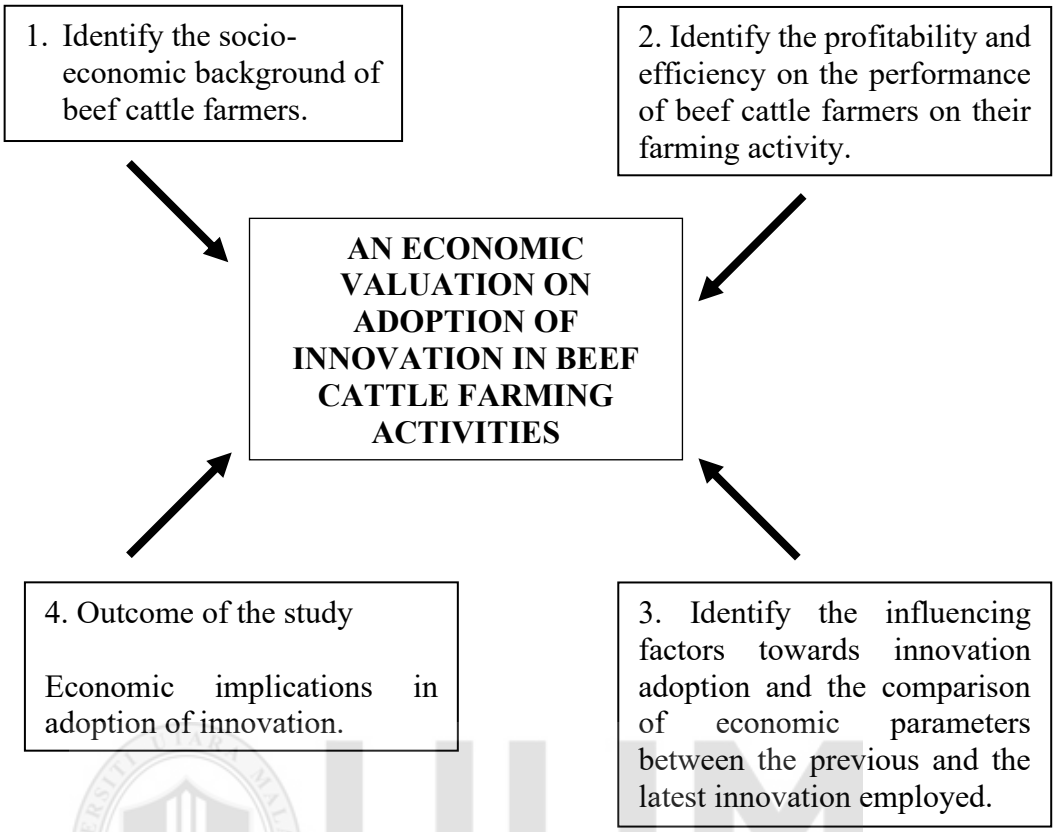


Figure 3.2
The research process
Source: Ali (2004)

3.3 Research Framework

The use of Diffusion of Innovation Theory, Utility Theory and the review of empirical studies conducted by previous researchers have formed a research framework, as shown in Figure 3.3. The research framework developed attempts to achieve three objectives of this study: (1) to examine the profitability and efficiency in beef cattle farming by personal characteristics of the farmers (region) and economic aspect (rearing technique and herd size); (2) to examine the economic implications of adopting innnovation in beef cattle farming in terms of the farm performance; and (3)

to analyse factors that influence the adoption of innovation in beef cattle farming. In a study by Paul et al. (2017) on the factors influencing farmers in the Caribbean Islands in using compost fertiliser, the variables such as age, education and experience were seen to influence the decisions of these farmers to adopt that kind of innovation.

Meanwhile, Roessali et al. (2011) found that the number of family labour, the expectation to increase income, education attainment and business risks were the four crucial factors influencing beef cattle farmers decision to increase beef cattle business scale in Central Java Province. The result of the research showed that the number of family labour and expectation to increase income had a significantly positive influence on farmers' decision to adopt the current innovation technique. In contrast, education level and business risks did not affect their decision to adopt innovation. However, this study did not measure the impact of adopting an innovation on farm performance.

Furthermore, Rathod et al. (2017) studied the acceptance of innovative techniques in cattle farming in India, namely AI by cattle breeders. It was found that education level, distance from extension office and herd size influenced their decisions. The higher the level of education, the closer the farm to the extension office, and the larger the farm size, the higher the tendency to use AI.

These three studies have been referred to as the foundation in determining factors to be used in determining the factors that influence the adoption of innovation among beef cattle farmers in Peninsular Malaysia. Hence, the variables employed in this study were modelled as 1) individual and farm factor; and 2) institution factor as in Figure 3.3.

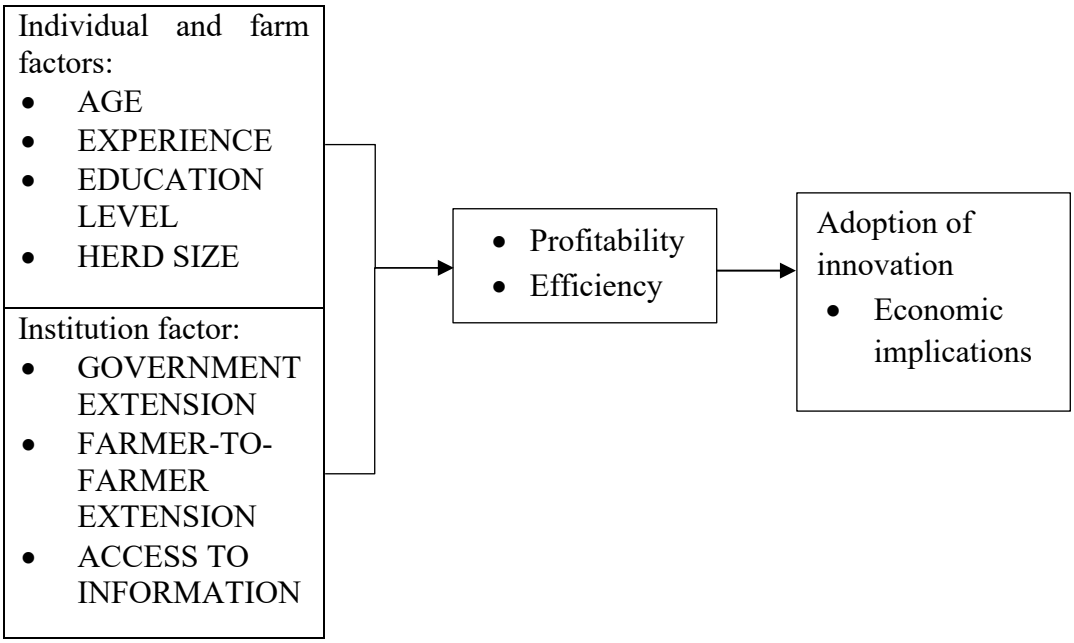


Figure 3.3
Research framework: Individual, farm and institutional factors that influence innovation adoption in beef cattle farming.

3.4 Research Model

This study categorised two groups of independent variables: Firstly, individual and farm factor, and secondly, institution factors. Descriptions related to individual factors, farm characteristics and institutional factors are as described below.

3.4.1 Individual and farm factor

Individual and farm factor consisted of variables 1) age, 2) experience, 3) education and 4) herd size.

Age is one of the standard variables used to explain the tendency of farmers to adopt innovation in beef cattle farming. It is believed that young and energetic farmers are more open-minded and ready for a new change (Rogers, 1983). This statement is also supported by a study related to the adoption of innovation among cattle farmers in Caribbean Island by Paul et al. (2017). They found that age has a significant and negative relationship with the adoption of innovation among cattle farmers in the Caribbean Island. The study stated that younger farmers were more involved in the production of compost from cattle dung. Compost production will benefit farmers as they can use compost as fertiliser on their farms. At the same time, farmers can earn extra money by selling the compost to other farmers. Previous studies have also found that ***experience*** can influence the adoption of innovation (Paul et al., 2017). Additionally, previous studies have also said that there are times when those involved in cattle farming have retired from employment in the private or government sector (Roessali et al., 2011).

On the other hand, ***education*** is also a vital independent variable to measure the adoption of innovation. A study by Suppadit et al. (2006) on adopting good agricultural practices for beef cattle farming in Thailand found that high educational farmers tend to accept and adopt Good Agricultural Practices (GAP). The different levels of education among farmers may affect perceptions and learning ability to digest the new skills and knowledge. Moreover, certain practices also need a high level of knowledge, such as health management (*disease prevention and healing*), breeding (*AI*), feeding (*quantity and quality of feed, and stock preparation*), environmental management (f*encing, housing, composing*) and drug-using. Education level was also found as

significant to the adoption of innovation conducted by several researchers such as Paul et al. (2017), Rathod et al. (2017), Roessali et al. (2011) and Wahyudi (2017).

The ***herd size*** on a farm is also one of the crucial variables in innovation studies. It is assumed that a greater herd size will lead a farmer to adopt innovation. Studies conducted by Rathod et al. (2017), Roessali et al. (2011) and Wahyudi (2017) found that herd size significantly influenced the adoption of innovation. Farmers need to employ innovation such as biosecurity by managing and monitoring the activities on the farm. Hence, it is essential to have excellent ideas, skills and knowledge to enhance farm productivity. Good networking with other stakeholders such as the DVS, wholesalers, retailers and beef cattle farmers is crucial to ensure the nation's self-sufficiency.

3.4.2 Institution factor

It is interesting to study how the transfer of innovation information from veterinary officers to cattle breeders and the farmers' association distributes information among the farmer's community. The ***government extension service*** is important in influencing farmers to adopt an innovation. For example, the guidance from extension workers will make farmers easily understand the new technology to increase beef production and overcome the health issues such as FMD. The previous study conducted in Maros Regency of South Sulawesi, Indonesia, showed that contact with extension service was significant towards farmers in Maros to adopt innovation among beef cattle farmers (Baba et al., 2019).

In many situations, extension agents play the role of a middleman in facilitating several tasks such as communication and policy implementations between government agencies such as the DVS and farmers. Besides, they have to convince farmers in adopting modern farming practices to increase productivity. However, extension agents must be convinced of the importance of using the technologies and well-prepared to use them (Allahyari, 2009). Extension services also aim to enhance farmers' attitudes, skills and knowledge through education and communication (Musa et al., 2019). They help farmers to improve production and profitability as well as introduce the new changes in farming practices using the current technologies improved from conventional methods. It is noticed that technology and farming practices are rapidly changing; thus, farmers must be versatile with an open attitude.

Meanwhile, the ***farmer-to-farmer extension*** has also become a vital element to distribute innovation among farmers. Kiptot and Franzel (2015) and Kiptot et al. (2016) found that farmer-to-farmer extension is more relevant because the farmers are closer to each other and indirectly share the same knowledge level. The significant result of farmer-to-farmer extension in adopting intensive rearing technique, crop residual as cattle feed and the compost use have proved that farmer-to-farmer extension influenced farmers to adopt such innovations in beef cattle farming (Baba et al., 2014, 2019; Paul et al., 2017).

Lastly, ***access to information*** has been also found as an important variable in innovation studies. Suppadit et al. (2006) stated in their study that farmers with more information sources tended to accept Good Agricultural Practice (GAP). Furthermore, other researchers have also employed this variable to measure the influence on

adopting innovation, including compost use and AI (Paul et al., 2017; Rathod et al., 2017). A significant result demonstrated that most farmers were influenced to adopt innovation due to easy access to information sources.

In conclusion, two categories of independent variables can influence innovation adoption in beef cattle farming. Ordinal logistic regression was employed to analyse the third objective of this study. The model of this study is detailed as below:

i. Ordinal logistic regression model:

$$f(\gamma_j(X)) = \log\left(\frac{\gamma_j(X)}{1-\gamma_j(X)}\right)$$

$$\log\left(\frac{P\{Y \le y_j/X\}}{P\{Y > y_j/X\}}\right) = \alpha_j + ßX_j, \quad ; j = 1, 2, \ldots, k-1$$

$$\log\left(\frac{P\{Y \le y_j/X\}}{P\{Y > y_j/X\}}\right) = \alpha_j + ß_1X_1 + ß_2X_2 + \ldots. + ß_pX_p \quad ; \text{X = independent variables}$$

$$\log\left(\frac{P\{Y \le y_j/X\}}{P\{Y > y_j/X\}}\right) = \alpha_j + ß_1\text{AGE} + ß_2\text{EXPERIENCE} + ß_3\text{EDUCATION} + ß_4\text{HERD SIZE} + ß_5\text{ACCESS TO INFORMATION} + ß_6\text{GOVERNMENT EXTENSION SERVICE} + ß_7\text{ FARMER-TO-FARMER}$$

Table 3.1 explains the definition of each variables used in the model.

Table 3.1
Definition of variables for the logit model

$f(\gamma_j(X))$	=	adoption of innovation in beef cattle farming; (1 = low; 2 = medium; 3 = high)
AGE	=	farmers' age (years)
EXPERIENCE	=	farmers' experience (years)
EDUCATION	=	level of education (1 = Degree; 2 = Diploma/ *Sijil Tinggi Pelajaran Malaysia*; 3 = *Sijil Pelajaran Malaysia*; 4 = Secondary school; 5 = Primary school; 6 = No formal education)
HERD SIZE	=	number of cattle (head)
ACCESS TO INFORMATION	=	access to information (1 = Strong disagree; 2 = Disagree; 3 = Agree; 4 = Strongly agree)
GOVERNMENT EXTENSION SERVICE	=	availability of extension services by the government (0 = No; 1 = Yes)
FARMER-TO-FARMER EXTENSION	=	availability of farmer-to-farmer extension services (0 = No; 1 = Yes)

Meanwhile, the expected signs for the explanatory variables of the logit model are shown in Table 3.2. The farmer's education, herd size, government and farmer-to-farmer extension service as well as access to information were expected to have positive signs, while age and experience were vice versa.

Table 3.2
The explanatory variables for the logit model

Explanatory variable	Explanation	Expected sign
AGE	The actual age of a farmer	-
EXP	Experience of a farmer	-
EDU	Education level of a farmer	+
HERD	The actual number of beef cattle at the farm	+
GOV	Availability of extension service by the Department of Veterinary Services	+
F-TO-F	Availability of farmer-to-farmer extension services by farmer's association.	+
ACCESS	The feasibility of farmers to access for information regarding innovation in beef cattle farming	+

On the other hand, the model for profitability and impact on adopting innovation is explained below:

$$\mu_B \dagger \mu_A = (TR_A - TC_A) - (TR_B - TC_B)$$
$$= \pi_A - \pi_B$$
$$= \Delta\pi$$

Table 3.3
Definition of variables for profitability model

μ_B	=	mean value before the adoption of innovation
μ_A	=	mean value after the adoption of innovation
TR_A	=	total revenue after adopting innovation (selling price x number of cattle sold)
TC_A	=	total cost after adopting innovation (feed, salary, utility, maintenance)
TR_B	=	total revenue before adopting innovation (selling price x number of cattle sold)
TC_B	=	total cost before adopting innovation (feed, salary, utility, maintenance)
π_A	=	profit earned after adopting innovation
π_B	=	profit earned before adopting innovation
$\Delta\pi$	=	changes of profit before and after adopting innovation

Hence, the profitability earned by the farmers has an impact on their farming performance. There was a difference in mean value before and after adopting innovation measured by paired sample t-test, which led to the changes in the farmers' profit before and after adopting innovation.

3.5 Research Hypothesis

The development of the research hypothesis was based on the assumptions that will influence the adoption of innovation. Hence, the research hypotheses are as below:

1. The cost of farming activity differs before and after adopting innovation. Farmers do not require high costs in their farming activity before adopting the innovation, but a more significant amount will be needed for their farm once they have adopted the innovation. Hence, it was assumed that adopting new technologies would incur a higher cost to the beef cattle farmers. However, it will also increase the total revenue that can cover the increase in the total cost.

2. Young and energetic beef cattle farmers are more comfortable in adopting innovation and are influenced to employ innovation. These farmers are still fresh to absorb new ideas for the new changes and improve their farming activity. Unfortunately, it does not happen to the older farmers since they are already comfortable with their current practice. This situation assumes that younger farmers will adopt innovation to enhance productivity and gain higher profits.

3. Experience is one of the crucial elements that will influence beef cattle farmers to adopt innovation. Farmers with less experience in cattle farming will adopt innovation than those who have more fabulous experiences. Experienced farmers are comfortable with the existing skills and practices implemented onto their farms. Thus, it can be assumed that farmers with less experience in farming will adopt innovation to improve the performance of their farms.

4. Education has played a role among beef cattle farmers to adopt an innovation. Those with high educational background tend to adopt innovation as they believe that it would enhance the performance of their farm by increasing the number of beef cattle. However, farmers with no or lower education backgrounds tend to reject and are not ready to adopt the innovation. So, it was assumed that farmers with a good educational background prefer to adopt innovation than those who do not.

5. The increasing number of cattle will lead farmers to employ certain technologies and practices to ease farm management. For example, the high number of beef cattle require a greater demand for feed. Hence, a skilful and knowledgeable farmer would process the crop residue to produce feed for the beef cattle at the farm. It was assumed that as the herd size increases, a farmer would tend to adopt the innovation.

6. The DVS has played a role since before Malaysia's independence in 1957 by providing extension services to the farmers. This service aims to assist farmers and improve the ruminant industry of Malaysia. Hence, having a good

relationship between the extension agents and farmers could enhance the farm's productivity and improve the existing practices in beef cattle farming. This study assumed that farmers will adopt innovation in beef cattle farming when they have attended an extension program from DVS.

7. The farmer-to-farmer extension has been known and practised in several African countries. This approach is much more comfortable for the farmers as they shared the current practices and the innovation in their circle. Those farmers who act as a leader understand the culture and beliefs among the farmers' community itself. Hence, it was assumed that this approach will influence farmers to adopt innovation in beef cattle farming.

8. Good access to information is vital for a farmer to receive current ideas and news regarding innovation. The ideas and technologies are widely disseminated on social media and among the farmers themselves. It was assumed that farmers who had easy access to information tend to adopt innovation than those who do not.

3.6 Questionnaire Design and Measurement

As for this study, the instrument was adapted based on established measures and theories. The underpinning theories for this study were the Utility Theory and the Theory of Diffusion of Innovation. Moreover, the items of the instrument were adapted from the previous studies. The Likert scale was used to measure specific items ranging from 1 to 4, namely, strongly disagree, disagree, agree and strongly agree. This 4-point

Likert scale was used to avoid social desirability or commonly known as bias. A socially desirable response makes respondents look good based on their opinions, values, behaviours and attitudes (Steenkamp et al., 2010). Besides, other items were measured from 1 to 3, namely poor, fair and good on the farmer's skills. Simultaneously, it is still necessary to conduct a pilot test to examine the instrument's reliability based on the Cronbach alpha value.

A set of questionnaire was adapted from the past studies, developed by the researcher and experts based on previous research and the current situation in cattle farming. The information gained from beef cattle farmers about the impact of adopting innovation in cattle farming is beneficial to the researchers. The seven variables mentioned earlier were adapted from the previous studies. In contrast, the financial elements such as cost, number of cattle sold, price per unit of cattle were limitedly studied by the previous studies, especially on the financial elements such as the liquidity and solvency. Table 3.4 explains each of the variables employed in this study.

Table 3.4
Types and methods for variables' measurement

Variables	Type of measurement	Response code
	Part A	
Adoption of innovation in beef cattle farming	Ordinal	Likert scale
	Part B	
Skills in farm management	Ordinal	Likert scale
	Part C	
Access to information	Ordinal	Likert scale
	Part D	
Grazing area	Dummy	No = 0 Yes = 1
Pen's cattle	Dummy	No = 0 Yes = 1
Weighing scale	Dummy	No = 0 Yes = 1
Lorry	Dummy	No = 0 Yes = 1
Family labour	Dummy	No = 0 Yes = 1
Number of family labour	Ratio	Open
Wage system	Ordinal	Daily = 0 Monthly = 1 Others = 3 None = 4
Non-family labour	Dummy	No = 0 Yes = 1
Number of family labour	Ratio	Open
Wage system	Ordinal	Daily = 0 Monthly = 1 Others = 3 None = 4
The inclination to adopt an innovation after received government extension service	Dummy	No = 0 Yes = 1
The inclination to adopt an innovation after received farmer-to-farmer extension service	Dummy	No = 0 Yes = 1

Registered farmer with DVS	Dummy	No = 0 Yes = 1
Species of the cattle	Nominal	Kedah Kelantan = 1 Charolais = 2 Brahman = 3 Limousin = 4 Droughtmaster = 5 Others = 6
Rearing technique	Nominal	Range feeding = 1 Integration = 2 Feedlot = 3
Reproduction technique	Nominal	Natural = 1 Artificial insemination = 2 Others = 3
Types of feed	Nominal	Forage = 1 Fodder = 2 Silage = 3 Paddy/ maize straw = 4 Agricultural waste = 5 Others =6
Food supplement	Dummy	No = 0 Yes = 1
Vaccination	Dummy	No = 0 Yes = 1
Biosecurity	Dummy	No = 0 Yes = 1
Total working hour	Ratio	Open
Total of cattle	Ratio	Open
Average of total cattle sold per year	Ratio	Open
The average price of cattle	Ratio	Open
The average cost of farm operation per month	Ratio	Open
The average income in cattle farming per year	Ratio	Open
Non-current asset	Ratio	Open
Current asset	Ratio	Open
Long term liability	Ratio	Open
Current liability	Ratio	Open
Part E		
Age	Ratio	Open
Gender	Ordinal	Male = 1

		Female = 2
Ethnicity	Nominal	Malay = 1 Chinese = 2 Indian = 3 Others = 4
Level of education	Ordinal	No formal education = 1 Primary school = 2 Secondary school = 3 *Sijil Pelajaran Malaysia* (SPM) = 4 Diploma/ STPM/ STAM = 5 Bachelor Degree = 6 Master Degree = 7 PhD = 8
Experience	Ratio	Open
Main occupation	Nominal	Cattle farmer = 1 Government = 2 Private sector = 3 Others = 4
Off-farm employment	Dummy	No = 0 Yes = 1
Distance from farm to DVS	Ratio	Open
Location	Nominal	Johor = 1 Kedah = 2 Kelantan = 3 Negeri Sembilan = 4
Farm size	Ratio	Open

3.7 Data Sources

This study employed primary sources, which is a standardised questionnaire. Smallholder farmers in Johor, Selangor, Kedah and Kelantan were essential in providing valid information regarding this study in rearing beef cattle.

3.8 Population and Sample

3.8.1 Sample Size

The unit of analysis in this study involved the individual beef cattle farmers in Peninsular Malaysia. The data obtained from the Department of Veterinary Services found that the population of cattle farmers in Malaysia is as presented in Table 3.5.

Table 3.5
The population of beef cattle farmers in 2017 at Peninsular Malaysia

State	Region	Number of beef cattle farmers by state	Number of beef cattle farmers by region	Sample size
Perlis	Northern	220	5,838	28
Kedah		3,845		
Pulau Pinang		412		
Perak		1,361		
Selangor	Central	741	2,043	10
Negeri Sembilan		1,302		
Melaka	Southern	724	3,377	16
Johor		2,653		
Pahang	East-coast	3,287	30,047	146
Terengganu		6,920		
Kelantan		19,840		
Total		**41,305**		**200**

Source: Department of Veterinary Services (2017b)

Sekaran (2006) mentioned that sampling size is a process to select a sufficient amount of elements from the population and that the collected data sample can represent the characteristic of the entire population. However, determining a sample size is a complex process where many factors should be considered. These factors include the types of sample, time and budget (Hair, 2015).

3.8.2 Sampling Procedure

The multi-stage sampling technique is the most appropriate method for this study. The chosen beef cattle farmers used a disproportionate stratified random sampling basis to ensure the population sample would cater further information within each cattle farmers' group. After that, a simple random sampling method was employed to ensure that each population has an equal chance to be selected. This method is agreed by Sekaran (2006) stating that using the simple random sampling procedure would make each sample in any population have an equal chance to be selected as a subject in a study.

Referring to the beef cattle farmers' population in Table 3.5, the estimated sample of beef cattle farmers was calculated according to four regions in Peninsular Malaysia. The method for calculating the estimated sample size below is referred from Hussin et al. (2014).

It is formulated as:

$$\frac{\text{Number of beef cattle farmers by region}}{\text{Total of beef cattle farmers in all regions}} \times 100$$

Hence, the estimated sample size for each region was calculated as shown in the next page:

Northern region: (5,838 / 41,305) x 100 = 14%

14% x 200 = **28**

Central region: (2,043 / 41,305) x 100 = 5%

5% x 200 = **10**

Southern region: (3,377 / 41,305) x 100 = 8%

8% x 200 = **16**

East coast region: (30,047 / 41,305) x 100 = 73%

73% x 200 = **146**

The estimated sample for this study was 200; Hair et al. (2014) mentioned that 200 is the critical sample size, while Roscoe (1975) stated that 30 to 500 is the appropriate sample size. On the other hand, Israel (1992) said that 200 to 500 units are the appropriate sample size for regression analysis. After the data collection process has been completed, it is identified that 233 respondents were successfully interviewed, which is more than the estimated sample size and it is considered sufficient for the study. This data was gathered during the pandemic of Coronavirus Disease 2019 (COVID-19), and it is a big challenge to gain a large sample size due to the movement restriction implemented by the Malaysian government.

3.9 Data Preparation

3.9.1 Pilot Study

Initially, a pilot study was conducted to discover the flaws in the questionnaire before proceeding with the actual survey. Drummond (2017) mentioned that a pilot study is practically essential to ensure that it can be conducted and enable the researchers to prepare for a larger sample and test the study instrument. Besides, it mainly tests the research instrument and acts as a trial to prepare for the actual data collection (Dikko, 2016). A pilot study was conducted from November 2019 to February 2020. The recommended sample size is between 20 to 50, which equals a sufficient number of respondents. The pilot study process involved 32 cattle farmers around Kedah who were interviewed in detail to gain as much information on the farming activity using the developed questionnaire. However, from the 32 samples taken, only 28 questionnaires were valid, and the data was put into SPSS to check for reliability. The Cronbach Alpha value for the reliability test must be within $0.7 \leq r \leq 1.0$ to ensure that useful items are employed for a study (Hussin et al., 2014). Most researchers commonly practice this procedure to ensure proper research, and unethical practice can be avoided (Drummond, 2017).

3.9.2 Reliability

The instrument's reliability is listed as one of the requirements in a study. It ensures that all the items in the questionnaire are relevant and easy to understand by the respondents. Yan Piaw (2006) mentioned that the instrument's reliability refers to a

particular instrument's ability to get the value of more or equal to 0.7 when the same measurement is re-use. Table 3.6 presents the reliability test analysis obtained from the SPSS.

Table 3.6
Reliability coefficients of the research instruments after the pilot study

Construct	Number of items	Alpha (n=28)
Adoption of innovation	9	0.897
Access to information	8	0.857

This study showed that the Cronbach Alpha value for nine items of adoption of innovation was 0.897 and the eight items of access to information were 0.857. Husin et al. (2014) define Cronbach Alpha as an internal consistency, which means that a set of items is related to each other in a group. A high value of Cronbach Alpha is proof that the items are suited to measure a construct. Technically, Cronbach Alpha is not a statistical test but is a reliability coefficient. The higher alpha coefficient, which is 0.7 and above, means that it is a reliable construct measurement (Heale & Twycross, 2015; Husin et al., 2014).

3.9.3 Validity

After the established reliability of the data was done, a procedure was followed to have an established validity instrument. Johnson and Wichern (2007) stated that Exploratory Factor Analysis (EFA) is a technique employed by researchers to reduce the number of variables into a small set of constructs that would summarise the variables' essential information.

Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity were conducted to demonstrate whether or not the data set suited to factor analysis and measure the sampling's adequacy. This procedure examines the factorability of the data set as a whole (Johnson & Wichern, 2007). Furthermore, Zulkepli et al. (2017) also mentioned that if Bartlett's Test of Sphericity is large and significant, and the KMO is equal or more than 0.5, it is assumed that the factorability in the data set does exist. The result of the validity test is shown below:

Table 3.7
Validity coefficients of the research instruments after the pilot study

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.792
Bartlett's Test of Sphericity	Approx. Chi-Square	154.344
	df	36
	Sig.	.000

In this study, the value of KMO was equal to 0.792, which was considered high. Meanwhile, the value of Bartlett's test of sphericity, χ^2 (36) =154.344, p<0.000, was considered as a significant and adequately sample for EFA.

3.10 Data collection

Data collection was conducted somewhere from March to September 2020 after obtaining permission from the DVS, Putrajaya. However, Movement Control Order (MCO) enforcement from 18th March to 12th May 2020 has postponed the data collection process for two months. During the Conditional Movement Control Order (CMCO) period from 13th May to 9th June 2020, the permission to cross the state

border was approved, allowing the data collection to start again. The researcher and the enumerator had to list all beef cattle farmers in an area as the requirement of stratified simple random sampling since the DVS did not provide the researchers with the list of beef cattle farmers in the area mentioned. Hence, the research team was required to identify all beef cattle farmers in that area and then select the respondents based on the simple random sampling technique where each sample had an equal chance to be selected.

A structured questionnaire and a face-to-face interview was the primary tool and method to conduct this project. A close visit around the farms was done to get first-hand observation on their practice and conduct a focus group discussion among the farmers and the extension agent(s) from DVS. This effort was to obtain better information regarding beef cattle farming activity and avoid bias in this study. There were 233 beef cattle farmers from four regions of Peninsular Malaysia, namely the northern, central, southern and east-coast region, who were selected as the respondents of this study.

3.11 Data Analysis

Data analysis is another crucial part to ensure all data are interpreted comprehensively. For the first objective, descriptive analysis was used to analyse the socio-economic profile of the respondents. The frequency, percentage, mean and standard deviation were discovered to determine the output of this study.

On the other hand, descriptive statistic was also used to analyse the second objective. The total cost is define as the overall cost of the farming activity including the farms' input and wages. Meanwhile, the total revenue was measured by multiplying the number of cattle sold and the price per unit sold. Then, the farms' profit was calculated using the total revenue (TR) – total cost (TC) formula.

Furthermore, the farm's liquidity is measured by identifying the current ratio and working capital. The current ratio is identified by measuring the current asset divided by current liability, while working capital was calculated based on the formula: total current farm assets – total current farm liabilities. The solvency is measured by identifying the debt-to-asset ratio, calculated by dividing the total farm liabilities and total farm assets. This kind of measurement examines and demonstrates the profitability and efficiency of the farming activity. The formula of the calculations is summarized as below:

Table 3.8
The formula in financial measurement

Measurement	Formula
Total cost	total farming cost (utility, farm's inputs, wages, and others)
Total revenue	number of cattle sold x average price per unit sold
Profit	total revenue ÷ total cost
	Liquidity
Current ratio	current asset ÷ current liability
Working capital	total current farm assets – total current farm liabilities
	Solvency
Debt-to-asset ratio	total farm liabilities ÷ total farm assets

Meanwhile, ordinal logistic regression was used to discover the third objective on factors that influence innovation adoption in beef cattle farming. Paired-samples T-

test was employed to run the fourth objective on the impact of adopting innovation in beef cattle farming. Before the analysis was run, a normality assumption was tested, which assumed that the data was normal (Appendix 2B). Hence, a paired-sample T-test can be employed for this study. Three indicators, namely; 1) total cost, 2) total revenue and; 3) profit, were used to measure the impact of adopting innovation.

Several assumptions must be fulfilled to run ordinal logistic regression, such as 1) model fitting information, 2) goodness-of-fit, 3) pseudo R-square, 4) test of parallel lines and 5) multicollinearity (Variance Inflation Factor and Tolerance value). The details of each assumption are explained as below:

i. Model fitting information

The p-value for model fitting information must be less than 0.05 to ensure the model were fit. The result found that $p < .000$, which means a well-fitted model (Appendix 2D).

ii. Goodness-of-fit

The goodness-of-fit in the other assumption is used to ensure the fitness of a model. The p-value for Pearson must be greater than 0.05 or approximately near 1.00. As the value is 0.849 and approaching 1.00, it means the model is almost fit. In this study, the p-value was 1.000, which was considered a well-fitted model (Appendix 2E).

iii. Pseudo R-square

The pseudo R-square (Nagelkerke value) for this study was equal to 0.614, almost to 0.7. Hence, this value was considered strong and ensured the model was fit (Appendix 2F).

iv. Test of parallel lines

The value for the test of parallel lines should be $p > 0.05$. In this study, the p-value was equal to 0.220, which was greater than 0.05, and it was assumed as a fit model (Appendix 2G).

v. Multicollinearity

Variance Inflation Factor (VIF) for all factors must range from 1 to 10 and tolerance value greater than 0.1 (Hussin et al., 2014). The analysis in this study found that the VIF and tolerance value followed the rules of thumb, and there was no multicollinearity problem for the data (Appendix 2H).

The summary of the analysis for each objective is in Table 3.9:

Table 3.9
Types of analysis for each objective

Objective	Analysis
1. To identify the socio-economics status of beef cattle farmers in Peninsular Malaysia.	Descriptive statistic
2. To examine the profitability and efficiency in beef cattle farming by region, herd size and type of innovation.	Descriptive statistic
3. To examine the economic implications of innovation adoption in beef cattle farming in terms of farm performance.	Paired sample T-test
4. To analyse factors that influence the adoption of innovation in beef cattle farming.	Ordinal logistic regression

CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter demonstrates results for each objective, followed by a discussion based on the results obtained. The first objective is to identify the socio-economic status of beef cattle farmers, followed by the second objective to examine the profitability and efficiency in beef cattle farming by region, herd size, and types of innovation. The third objective is to analyse factors that influence the adoption of innovation in beef cattle farming, and the final objective is to examine the impact of innovation adoption in beef cattle farming in terms of farm performance.

4.1 Introduction

This chapter discusses the reliability and validity of the instruments before elaborating more on the findings from the four study objectives. The socio-economics profile of beef cattle farmers and their farm background has been explained, followed by the second objective on the profitability and efficiency of beef cattle farming. The following objective discusses the economic implications of adopting innovation in terms of the farm's performance while the final objective elaborates on the factors that influence innovation adoption.

4.2 Reliability and Validity of Research Instrument

The reliability and validity of the instrument were measured once data collection had been completed. This practice is to ensure that all data gained among 28 respondents are reliable and valid for this study.

4.2.1 Reliability

The reliability analysis is an analysis that examines the consistency of a research instrument (Hussin et al., 2014). Based on Table 4.15, the Cronbach Alpha value for the dependent variable, adoption of innovation was 0.944, while the Cronbach Alpha value for access to information was 0.730 after the data collection. The Cronbach Alpha value for both variables was greater than 0.7, showing that the developed instrument is reliable and consistent (Yan Piaw, 2006).

Table 4.1
Reliability coefficients of the research instruments after the data collection

Construct	Number of items	Alpha (n=233)
Adoption of innovation	8	0.944
Access to information	8	0.730

4.2.2 Validity

After completing the data collection, validity was checked once again to identify the items that may influence a variable, since the set of items may also become another set of variables (Hussin et al., 2014). Referring to Table 4.16 below, the value of Kaiser-

Meyer-Olkin (KMO) was 0.913 and the value of Bartlett's test of sphericity, $\chi 2$ (36) =154.344 with $p<0.000$, which was considered significant and adequate to summarise the variables' essential information (Johnson & Wichern, 2007).

Table 4.2
Validity coefficients of the research instruments after the data collection

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.913
Bartlett's Test of Sphericity	Approx. Chi-Square	1780.002
	df	28
	Sig.	.000

4.3 Socio-economics Profile of the Respondents

Objective one: To identify the socio-economics status of beef cattle farmers in Peninsular Malaysia.

a. Socio-economics profile of beef cattle farmers in Peninsular Malaysia

The findings of socio-economics background among beef cattle farmers are explained in Table 4.3. Among the 233 respondents, about 96.1% (224) were male, and 99.6% (232) were Malay. Meanwhile, about two-thirds (61.4%) of the farmers had secondary school education with a mean age of 48 years old. Further, 45.5% of them were aged between 19 to 48 years old. It was interesting to say that most beef cattle farmers had a good experience in beef cattle farming as most of them have had 13 years of experience in this activity. On the other hand, 63.5% (148) of farmers were involved with off-farm employment, while 36.5% were full-time farmers.

Table 4.3

Socio-economics profile of the respondents in Peninsular Malaysia

Characteristic	Frequency (n=233)	Percentage (%)	Mean	SD
Age (years)			48.4	13.65
19 – 28	22	9.4		
29 – 38	44	18.9		
39 – 48	40	17.2		
49 – 58	69	29.6		
59 – 68	44	18.9		
69 – 78	11	4.7		
79 – 88	3	1.3		
Gender				
Male	224	96.1		
Female	9	3.9		
Ethnicity				
Malay	232	99.6		
Others, Siamese	1	0.4		
Level of education				
Master Degree	1	0.4		
Bachelor Degree	10	4.3		
Diploma/ STPM/ STAM	26	11.2		
SPM/ MCE	84	36.1		
Secondary school	59	25.3		
Primary school	42	18.0		
None	11	4.7		
Years of experience in beef cattle farming (years)			13.1	11.38
1 – 10	142	60.9		
11 – 20	49	21.0		
21 – 30	24	10.3		
31 – 40	14	6.0		
41 – 50	3	1.3		
51 – 60	1	0.4		
Off-farm employment				
Yes	148	63.5		
No	85	36.5		

b. Socio-economics profile of beef cattle farmers by regions in Peninsular Malaysia

Table 4.4 explains that the mean age of farmers in the central region was 41 years old, which is younger than the overall mean age, and most farmers in each region were male. Furthermore, most farmers had secondary education and have had seven to 11 years of schooling. There were no apparent differences in farmers' education

levels in the respective regions, where most of them have a secondary education level. However, farmers in the southern region had a greater experience than other farmers on the northern, central and east coasts because they already had 18 years of experience in beef cattle farming. The locality factor has somehow contributed to the involvement of farmers in this sector. Malaysian Veterinary Institute in Kluang, Johor, has become one of the research centres in Malaysia and people around Johor get more exposure to the information regarding innovation in beef cattle farming. This situation can encourage more people to get involved to increase the production of beef cattle in Malaysia. Moreover, farmers in the respective regions also have other sources of income instead of beef cattle farming.

Table 4.4
Socio-economic profile of the respondents according to four regions in Peninsular Malaysia

Characteristic	Northern region	Central region	East-coast region	Southern region
Age, years (mean)	48	41	49	50
Experience, years (mean)	13	6	13	18
Gender (%)				
Male	97.1	100	96.2	93.3
Female	2.9	0	3.8	6.7
Education (%)				
University (12 years and above)	14.3	27.3	14.0	23.3
Secondary school (7 to 11 years)	57.1	63.6	60.5	70.0
Primary school (1 to 6 years)	14.3	9.1	21.7	6.7
No school	14.3	0	3.8	0
Off-farm employment (%)				
Yes	51.4	90.9	59.9	86.7
No	48.6	9.1	40.1	13.3

4.3.1 Farm Background

Table 4.5 shows the farm background of beef cattle farmers in Peninsular Malaysia. It was found that most of the farm was operated near to the DVS, where the average distance is about 12.4 kilometres (km). Farmers tend to be away from innovation if the distance is too far from the DVS or any veterinary extension centre. However, with the acceptable distance, farmers can receive extension service from the DVS officers specifically related to the innovation in beef cattle farming. Besides, most beef cattle farmers owned about 3.5 acres of land, and the mean of working hours at the farm is about 4.1 hours per day. There were 4.7% (11) farmers who did not own any land and practise range feeding farming techniques where beef cattle are scattered around the village.

Furthermore, most farmers also had an average number of 23 cattle at their farm. The farm size and working hours were reasonable with the average cattle holding of each farmer. Most farmers allocate about two hours in the morning and two hours in the evening for their farming activity. On the other hand, about 38.2% (n=89) and 15.5% (n=36) of them hired family and non-family labour, while 46.3% (108 farmers) ran their farming activity independently. Almost 78.5% (n=183) of the farmers had grazing areas while others were not, and they get the supply of feed such as self-collection of forages from any available sources, which is time-consuming.

Moreover, there are several types of rearing techniques, including range feeding, integration and feedlot. Integration and feedlot technique has been introduced as the innovation in beef cattle farming that helps farmers to produce high-quality beef with

higher earnings. The findings showed that only 28.8% (n=67) of farmers had employed the range feeding techniques while another 33.4% (n=78) employed the mix techniques in rearing cattle. AI has also been introduced as one of the assisted reproduction techniques in cattle farming and about 49.4% (n=115) of farmers preferred natural mating, while 31.3% (n=73) were used to AI.

Table 4.5
Farm background

Item	Frequency (n=200)	Percentage (%)	Mean
Farm distance to DVS (kilometre)			12.4
1 – 20	202	86.7	
21 – 40	28	12.0	
41 – 60	3	1.3	
Farm size (acre)			3.5
0	11	4.7	
0.1 – 10	210	90.1	
10.1 – 20	7	3.0	
20.1 – 30	4	1.7	
30.1 – 40	1	0.4	
Mean of working hour			4.1
Mean number of cattle			23.0
Labour			
Family labour	89	38.2	
Non-family labour	36	15.5	
No labour	108	46.3	
Grazing area			
Yes	183	78.5	
No	50	21.5	
Rearing technique			
Range feeding	67	28.8	
Integration	42	18.0	
Feedlot	46	19.7	
Range feeding and integration	38	16.3	
Range feeding and feedlot	15	6.4	
Integration and feedlot	20	8.6	
Range feeding, integration and feedlot	5	2.1	
Reproduction technique			
Natural	115	49.4	
Artificial insemination	73	31.3	
Natural and artificial insemination	45	19.3	

Table 4.6 demonstrates the farm background according to the four regions in Peninsular Malaysia. The mean distance to the DVS was between 8.4 to 22.7 kilometres, which explains that it is not difficult for the farmers to reach for extension services from the DVS. Meanwhile, the farmers' farm size was between 2.9 to 5 acres and the mean of working hours in the central region was the longest with 7.2 hours per day. The majority of farmers, except those in the northern region, owned a grazing area for the cattle. This study captured an exciting finding in the east-coast region when 45.9% of farmers had fully-practised AI on their cattle. However, a different situation occurred in the other three regions where natural mating was preferred to improve production.

Table 4.6
Farm background according to four regions in Peninsular Malaysia

Characteristic	Northern region	Central region	East-coast region	Southern region
Farm distance to DVS, km (mean)	19.3	20.3	8.4	22.7
Farm size (mean)	5.0	3.0	2.9	4.6
Working hour (mean)	4.6	7.2	3.8	4.3
Herd size (mean)	42	40.9	11.9	57.1
Grazing area, % (n)				
Yes	48.6 (17)	63.6 (7)	86.0 (135)	80.0 (24)
No	51.4 (18)	36.4 (4)	14.0 (22)	20.0 (6)
Reproduction technique, % (n)				
Natural	80.0 (28)	100 (11)	31.8 (50)	86.7 (26)
Artificial insemination	2.9 (1)	0	45.9 (72)	0
Natural and artificial insemination	17.1 (6)	0	22.3 (35)	13.3 (4)

Table 4.7 shows the relationship between farm size and farmers' working hours. It was noted that 74 farmers who had less than two acres of land spend equal to or less than three hours daily at the farm. Meanwhile, about 52 farmers who owned greater than 2.1 acres of land spend equal to or more than 3.1 hours managing the farm. However,

the 40 farmers with the same land size spend less than two hours doing their farm works.

Table 4.7
The ratio frequency between farm size and working hour

Working hour (hours)	Farm size (acres)	
	≤ 2.0	≥ 2.1
≤ 3	74	67
≥ 3.1	40	52

According to Table 4.8, 135 farmers owned not less than two acres of land hold equal to or less than 50 cattle. At the same time, 68 farmers owned a bigger farm size but held the same herd size category. Furthermore, as the herd size is getting bigger, more farmers need a bigger farm size, and 24 of them hold equal to or more than 51 beef cattle. Farmers usually got other feed sources such as pellets, agricultural waste and household waste instead of letting the cattle graze at the farm.

Table 4.8
The ratio frequency between farm size and herd size

Herd size	Farm size (acres)	
	≤ 2.0	≥ 2.1
≤ 50	135	68
51 to 100	6	18
≥ 101	0	6

4.3.2 Adoption of Innovation in Beef Cattle Farming by Likert Scale

The adoption of innovation in beef cattle farming was recognised as the dependent variable of this study. This construct was measured using a 4-point Likert scale: strongly disagree, disagree, agree and strongly agree.

Referring to Table 4.9, the frequency and percentage of each item showed that most beef cattle farmers received information regarding innovation, making them adopt it. They have also agreed that innovation will improve farm production as they can have better farm management. However, 45.5% (106) of farmers believed that adopting innovation involves a high cost of farming.

Table 4.9
The frequency and percentage by items for the adoption of innovation in beef cattle farming

Items	n = 233 (100%)			
	1 Strongly disagree	2 Disagree	3 Agree	4 Strongly agree
1. I adopt innovation for beef cattle farming.	16 (6.9)	22 (9.4)	138 (59.2)	57 (24.5)
2. I adopt innovation to improve the productivity of the farm.	15 (6.4)	26 (11.2)	124 (53.2)	68 (29.2)
3. In my opinion, the adoption of innovation is vital in beef cattle farming.	7 (3.0)	19 (8.2)	119 (51.1)	88 (37.8)
4. I gained benefits from adopting innovation.	10 (4.3)	32 (13.7)	110 (47.2)	81 (34.8)
5. I am well informed of the innovation introduced in beef cattle farming.	20 (8.6)	28 (12.0)	124 (53.2)	61 (26.2)
6. Adopting innovation does not involve high costs.	24 (10.3)	82 (35.2)	74 (31.8)	53 (22.7)
7. I have been exposed to the importance of innovation in beef cattle farming.	25 (10.7)	44 (18.9)	115 (49.4)	49 (21.0)
8. Adopting better farm management is also counted as embracing innovation.	9 (3.9)	33 (14.2)	108 (46.4)	83 (35.6)

Next, the level of the adoption of innovation was tested. The total score was grouped into four categories: no adoption (total score = 8), low (total score from 9 to 16),

moderate (total score from 17 to 24) and high (total score from 25 to 32). This formulation is measured as eight items in the dependent variables multiplied by (1) representing strongly disagree; hence the total score is 8. Table 4.10 demonstrates that about 48.1% of respondents had a high level of innovation adoption, while 1.7% had no adoption of innovation in beef cattle farming.

Table 4.10
Level of adoption of innovation in beef cattle farming

Level	Frequency	Percent
Not adopt (8)	4	1.7
Low adoption (9 to 16)	32	13.7
Moderate adoption (17 to 24)	85	36.5
High adoption (25 to 32)	112	48.1
Total	n = 233	100.0

4.4 The Profitability and Efficiency of Beef Cattle Farming

Objective two: To examine the profitability and efficiency in beef cattle farming by region, herd size, and type of innovation.

The profitability of beef cattle farming activity was measured by calculating the total revenue and the total cost. Hence, the profit earned can explain the profitability of each farm in this study.

4.4.1 Financial Information of the Farm

Table 4.11 below shows the profitability of the farm by measuring the total revenue, the overall cost per year and the sale price of the cattle. It was noted that the farm's total revenue was estimated by multiplying the total of cattle sold and the unit price. Ashley et al. (2018) and Young et al. (2014) have also employed this method to examine the financial metrics of forage technology adoption among smallholder cattle farmers in Cambodia. The farmer will get the positive value of profit if the total cost is lower than the total revenue. The median of the cow's price ranged from RM 3,500 to RM 4,000 before and after adopting innovation.

Meanwhile, the total cost included the feed, maintenance of the farm and utility expenses, which was divided into two categories: (1) rearing for one unit of beef cattle and (2) rearing the beef cattle in one acre of land. The monthly cost is about RM 58 per one unit of beef cattle, while the monthly cost for one acre of land in rearing beef cattle is about RM 445.40. The details and calculations involved are presented in Appendix 2K. On the other hand, before adopting innovation, the profit median was RM 18,000, and after adopting innovation, it increased to RM 34,080.

Table 4.11
Financial information of the farm

Variable(s)	Frequency, n= 233		Median, RM	
	Before	After	Before	After
Total revenue, RM			24,000	45,000
≤ 100,000	209	173		
101,000 – 200,000	20	25		
201,000 – 300,000	2	15		
≥ 301,000	2	20		
Overall cost (per year), RM			4,800	6,000
≤ 1,000	15	7		
1,001 – 5,000	111	84		
5,001 – 10,000	61	48		
≥ 10,001	46	94		
The sale price of cattle, RM			3,500	4,000
≤ 3,000	95	42		
3,001 – 6,000	132	167		
6,001 – 9,000	5	19		
≥ 9,001	1	5		
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		

4.4.2 Profitability according to Region

Table 4.12 shows the range of profit earned by all farmers in four regions of Peninsular Malaysia before adopting innovation. About 13 respondents from the southern region with a profit greater than RM 200,000 were excluded and considered outliers. This situation was the same as in the central and northern regions. Only nine of 11 respondents were included for the central region, and only 32 out of 35 were involved in the northern region. The median cost before adopting innovation shows that the southern and central regions were the lowest with RM 3,600 but increased to 25% and 40% after adopting innovation.

On the other hand, the median profit for the central region was the highest before adopting innovation with RM 60,400. However, after adopting innovation, the southern region appeared the highest for the median profit with RM 75,200, while the central region was RM 72,000, followed by an east-coast and northern region with RM 9,000 and RM 7,600, respectively. The southern region represented by Johor state showed the highest percentage changes is due to the strategic location of the Malaysian Veterinary Institute in Kluang, Johor, as one of the stop centres for knowledge and skills distribution among beef cattle farmers around Johor. A good location of an extension centre plays a successful role in agriculture activity (Rathod et al., 2017). Besides, the integrated farming system is also well-practised in Johor since they have many palm oil plantations. The sufficient area for grazing reduced the cost of weeding and increased fruit yield as less competition between the grass and oil palm (Md. Said & Man, 2014). Hence, the productivity of cattle and oil palm can be improved as well as the farmers' profitability and producing a holistic management system (Reddy, 2016).

Table 4.12
The profitability in beef cattle farming before and after the adoption of innovation according to four regions

Profitability in beef cattle farming	Southern region, *n=17*		Northern region, *n=32*		East-coast region, *n=157*		Central region, *n=9*	
	Before	After	Before	After	Before	After	Before	After
Median of total cost (TC), RM	3,600	4,800	4,800	12,000	4,800	6,000	3,600	6,000
Δ of TC, RM (%)	1200 (25%)		7,200 (60%)		1,200 (20%)		2400 (40%)	
Median of total revenue (TR), RM	10,500	80,000	6,000	19,600	10,000	15,000	64,000	78,000
Δ of TR, RM (%)	69,500 (86.9%)		13,600 (69.4%)		5,000 (33.3%)		14,000 (17.9%)	
Median of profit (TR – TC), RM	6,900	75,200	1,200	7,600	5,200	9,000	60,400	72,000
Δ of profit, RM (%)	68,300 (90.8%)		6,400 (84.2%)		3,800 (42.2%)		11,600 (16.1%)	

4.4.3 Profitability according to Herd Size

Table 4.13 demonstrates the median profitability according to the herd size. The percentage changes for the profitability of three groups, namely; 1) equal or less than 50; 2) 51 to 100; and 3) equal or more than 101 for before and after adopting innovation were 34.7%, 9%, and 29.4%. As the herd size increases, it did not confirm that the profit will highly increase. This situation depends on how the farmer manages the farm and the attention paid by the extension workers at the planning stage, as well as the economic and technical aspects (Blazy et al., 2015; Sotamenou & Parrot, 2013).

In terms of the economy of scale, factors such as buying input at a lower price and the efficiency in using labour are crucial to ensure that a farmer can earn a higher profit from this farming activity. Farmer's effort to plant Napier at the farm and high skills in producing cattle feed, including silage and agriculture residuals, is essential to reduce the farming cost and increase profit margin. Meanwhile, hiring labour by not only focusing on one specialisation is also a bonus to a farmer. The farmer does not have to spend more expenses hiring more labour with a specific skills.

Table 4.13
The profitability in beef cattle farming before and after the adoption of innovation according to herd size

Variable(s)	Number of beef cattle					
	≤ 50		51 - 100		≥ 101	
	Before	After	Before	After	Before	After
Median of total cost, (TC), RM	4,500	6,000	21,000	36,000	3,500	37,200
Δ of TC, RM (%)	1,500 (25%)		15,000 (41.7%)		33,700 (90.6%)	
Median of total revenue (TR), RM	24,000	35,000	275,000	315,000	540,000	742,500
Δ of TR, RM (%)	11,000 (31.4%)		40,000 (12.7%)		202,500 (27.3%)	
Median of profit, RM	17,800	27,250	254,000	279,000	498,000	705,300
Δ of profit, RM (%)	9,450 (34.7%)		25,000 (9%)		207,300 (29.4%)	

Based on the personal interviews conducted between the researcher and respondents, several matters were concerned, such as the price competition of import and local beef and the oversupply of local beef since the consumer would instead buy the cheaper imported compared to the local beef. Moreover, the high cost of feed nowadays has affected farmers' profitability as it does not show the price reduction. Hence, the farmers' community hoped that the responsible parties would control this matter so

that some of them would not feel exploited. Some individual farmers have agreed that cooperation should be formed between the prominent and unfamiliar beef cattle farmers. This situation was mentioned because customers will usually buy from prominent cattle farmers instead of unfamiliar farmers. So, the cooperation between these two farmers will support each other and give other farmers a chance if they do not have enough cattle supply during any festive or Eid al-Adha.

4.4.4 Profitability according to Rearing Technique Employed

Table 4.14 below demonstrates the cost, revenue and profitability of beef cattle farming by adopting different rearing techniques. The median profit for integration technique was shown the highest, followed by feedlot and range feeding techniques. Results also demonstrated that 67% of changes of profit were from the integration technique as it is a resource-saving practice. The cattle can freely graze at the palm oil plantation, which leads to the preservation of the environment (Md. Said & Man, 2014). Meanwhile, there were 51% changes in the profitability before and after adopting the feedlot technique. Beef cattle farmers did not widely practice this technique as it needs a proper housing system, feeding, reproduction, health management and faeces utilisation (Baba et al., 2014). Range feeding was the least effective yet only contributed 27.5% changes in the profitability. This technique was not recommended as it is not adopting good husbandry practices such as bio-security, and the cattle are not placed at a farm, which can harm the road users and the villagers. In conclusion, the integration or integrated farming system is the best farming practice as it reduces cattle feed cost and enhances environmental sustainability (Md. Said & Man, 2014).

Table 4.14
The profitability in beef cattle farming before and after the adoption of innovation according to the rearing techniques

Variable(s)	Range feeding		Integration		Feedlot	
	Before	After	Before	After	Before	After
Median of total cost (TC), RM	3,600	6,000	5,700	9,600	6,000	16,800
Δ of TC, RM (%)	2,400 (40%)		3,900 (40.6%)		10,800 (64.3%)	
Median of total revenue (TR), RM	21,000	30,000	26,000	70,000	32,000	73,500
Δ of TR, RM (%)	9,000 (30%)		44,000 (62.9%)		41,500 (56.5%)	
Median of profit, RM	17,400	24,000	19,200	58,200	24,400	49,800
Δ of profit, RM (%)	6,600 (27.5%)		39,000 (67%)		25,400 (51%)	

4.4.5 Profitability according to the Types of Innovations

The current technologies and practices introduced in beef cattle farming are also known as innovations. Besides integration farming technique, intensive rearing technique or commonly known as feedlot, are the practices used by the farmers to have better production and minimize the losses at the farm. Silage is also known as one of the feed resources for cattle during climate changes, especially drought or flood seasons. The limitation of forages during that time can be substituted with silage. AI is the technology used by farmers to have a good breed of cattle and to increase production. Vaccination is also essential to avoid infectious diseases, while biosecurity is a well-managed practice to handle cattle at the farm, including waste disposal and drainage.

The profit changes for integration rearing technique is the highest with 67% compared to the other types of innovation. It was followed by silage as cattle feed with 60.2% profit changes. The feedlot or intensive rearing technique showed the third-highest of profit changes with 51%. Meanwhile, vaccination, biosecurity, and AI with 42%, 35.5%, and 33% profit changes. The findings clearly show that innovation in practices or technologies contributes to the farm's production and profitability.

However, in terms of the farming cost, feedlot or intensive rearing technique showed the highest changes of the total cost before and after implementing this practice with 64.3% followed by integration rearing technique with 40.6% and silage as cattle feed with 40%. Meanwhile, AI and biosecurity had lower total cost changes with 28.6%, and vaccination shows only 6.7% for the changes in total cost. In conclusion, integration and silage are two innovations are that vital for beef cattle farming. Instead of environmental sustainability, integrated farming system and innovation of silage have benefited farmers economically as it is cost-efficient, a solution to farmers' problem (Md. Said & Man, 2014; Raza et al., 2021; Reddy, 2016). Table 4.15 demonstrates the details of profit, revenue, and cost of each innovation discussed.

Table 4.15
The profitability for before and after adopting the innovations in beef cattle farming

Variable(s)	Integration		Feedlot		Artificial insemination		Silage		Biosecurity		Vaccination	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Median of total cost (TC), RM	5,700	9,600	6,000	16,800	6,000	8,400	3,600	6,000	6,000	8,400	6,000	7,200
Δ of TC, RM (%)	3,900 (40.6%)		10,800 (64.3%)		2,400 (28.6%)		2,400 (40%)		2,400 (28.6%)		1,200 (16.7%)	
Median of total revenue (TR), RM	26,000	70,000	32,000	73,500	14,000	19,000	12,500	48,000	15,000	22,500	12,750	22,500
Δ of TR, RM (%)	44,000 (62.9%)		41,500 (56.5%)		5,000 (26.3%)		35,500 (74%)		7,500 (33.3%)		9,750 (43.3%)	
Median of profit, RM	19,200	58,200	24,400	49,800	6,000	8,950	9,000	22,600	6,000	9,300	6,500	11,200
Δ of profit, RM (%)	39,000 (67%)		25,400 (51%)		2,950 (33%)		13,600 (60.2%)		3,300 (35.5%)		4,700 (42%)	

4.4.6 Liquidity and Solvency

Table 4.16 below shows the value of liquidity and solvency. The current ratio was measured by dividing the current assets and current liabilities, and the results for three categories of herd size were 1.669, 5.792 and 2.251, respectively. The current ratio is understood as the ability of a farmer to pay short term obligations. This study found that those farmers with less than 50 cattle were more willing to pay than those with bigger herd sizes. Meanwhile, the working capital was RM 2,581.08, RM 74,438.90 and RM 48,716.67 for farmers with less than 50 cattle, 51 to 100 cattle and greater than 101 cattle. Working capital is a farm operational efficiency that can be seen in the expenses of cattle feed and other inputs.

On the other hand, solvency was calculated to measure the efficiency of beef cattle farming activity. The debt-to-asset ratio was calculated by dividing the total farm liabilities and total farm assets. Hence, the amount was 0.305, 0.156 and 0.229 for three categories of herd size. Farmers with less than 50 cattle had performed their business excellently than those who hold 51 cattle and above. In a particular condition, expanding the cattle production and adopting an advanced innovation will worsen the performance in cattle farming due to limited working capital (Roessali et al., 2011). The availability of labour is crucial to meet the need for forages.

Hence, the liquidity and solvency are vital to check of the farm's efficiency and their performance after adopting innovation in beef cattle farming.

Table 4.16
The liquidity and solvency measured by the mean

Measure / Number of cattle	≤ 50	51 - 100	≥ 101
Liquidity:			
Current ratio (Current asset ÷ current liability)	1.669	5.792	2.251
Working capital, RM (Current asset – Current liability)	2,581.08	75,438.90	48,716.67
Solvency:			
Debt-to-asset ratio (Total farm liabilities ÷ total farm assets)	0.305	0.156	0.229

4.5 The Economic Implications of Innovation Adoption in Beef Cattle Farming

Objective three: To examine the economic implications of innovation adoption in beef cattle farming in terms of farm performance.

4.5.1 The Economic Implications on the Total Cost and Total Revenue

The farming cost and total revenue are different before and after adopting innovation. A significant amount is necessary when a farmer decides to adopt innovation at his or her farm. This situation is similar to the total revenue. The total revenue will also increase as the number of cattle sold increases with a higher price.

The total cost and total revenue are vital in farming activity. The paired-samples T-test examined the effectiveness of adopting innovation and compared the mean value of the variables in this study.

Based on the results presented in Table 4.17, there was a significant difference in the scores for before (M=640.60, SD=1,011.93) and after (M=1,336.24, SD=1,870.77) adopting innovation; t (233) = -7.852, p = 0.000. These results suggest that cost affects innovation adoption, as the total cost has increased when beef cattle farmers adopt the innovation. This situation was due to the innovation introduced in beef cattle farming that requires a larger amount of capital to sustain and enhance the production in this sector. However, the increasing total cost has been covered by the expansion of the total revenue. This situation can be explained as the number of beef cattle sold increases, and the price sold is higher.

For the total revenue, the result showed a significant difference in the scores for before (M=41,952.36, SD=57,763.43) and after (M=104,881.16, SD=151,383.80) adoption of innovation in beef cattle farming; t (233) = -7.250, p = 0.000. This result shows that when the beef cattle farmers adopt the innovation, the total revenue increases. This situation is a good sign for the extension workers to enhance the use of innovation among farmers as it will improve the farmers' standard of living and boost Malaysian economics. Furthermore, the changes in profit also demonstrated a good value after it was deducted from the total cost. Overall, before adopting the innovation, farmers earned about RM 41,311.76, which was then increased to RM 103,544.92 after adopting the innovation.

Table 4.17
The relationship between innovation and the financial indicators

Variable(s)		Mean	SD	t	df	Sig. (2-tailed)
Total cost (TC)	Before	640.60	1,011.93	-7.852	233	0.000
	After	1,336.24	1,870.77			
Total revenue (TR)	Before	41,952.36	57,763.43	-7.250	233	0.000
	After	104,881.16	151,381.80			

Δ in profit (TR – TC) :

BEFORE = RM 41,952.36 – RM 640.60
= RM 41,311.76

AFTER = RM 104,881.16 – RM 1,336.24
= RM 103,544.92

The finding of this study is almost similar to the research conducted in Cambodia on adopting best practice health and husbandry interventions. Farmers from three 'high intervention' (HI) villages successfully earned higher profits than the farmers from three 'low intervention' (LI) villages (Young et al., 2014). The HI farmers received an extension program, including vaccination, forage improvement and veterinary training. Meanwhile, LI farmers have only received the vaccination for their cattle. Young et al. (2014) stated that those farmers who were involved in HI villages had increased their income by less than double (40%), double (43%) or more than double (17%). However, about 49 farmers were unsure whether or not their income increased, and 10 farmers stated that their income did not increase after engaging in this program. Nevertheless, surprisingly, a farmer from LI villages stated that his income increased from the project. It is understood that innovation impacts the farmers differently, and collaboration among all parties is a must to ensure the success of a project. Adopting

innovations has led to improved farm productivity, farm expansion, employment opportunity and higher income.

Based on the result and discussion above, the null hypothesis was rejected since there were differences in the total cost and total revenue before and after adopting innovation in beef cattle farming.

4.5.2 The Economic Implications on the Profit

Profit was expected to increase when the farmers adopted the innovation. Table 4.18 below demonstrates the difference in profits of each region in Peninsular Malaysia. For the northern region, there was a significant difference in the scores of profit for before (M=48,040.0, SD=74,738.4) and after (M=148,727.4, SD=192,481.2) adopting innovation; t (34) = -4.494, p = 0.000. Based on the result, it shows that profit affects the adoption of innovation in beef cattle farming.

Furthermore, the central region also showed a significant difference in the scores of profit before adopting innovation (M=92,690.9, SD=47,016.5) and after adopting the innovation (M=156,827.3, SD=121,198.4); t(10) = -2.445, p = 0.036, ($p<0.05$). The same situation occurred for the east coast and southern region as the profit of these two regions showed a significant difference. The profit score for the east coast region was (M=27,544.5, SD=49,127.4) and (M=41,247.1, SD=67,034.1), t (156) = -3.143, p=0.002, ($p<0.05$), which demonstrated an improvement of the profit after they have had to adopt innovation in beef cattle farming. The result for the southern region was

also similar to (M=31,943.3, SD=35,548.1) and (M=243,160.0, SD=197,110.2), t (29) = -5.774, p=0.000.

Table 4.18
The relationship between profit and four regions in Peninsular Malaysia

Variable(s)		Mean	SD	t	df	Sig. (2-tailed)
Northern	Before	48,040.0	74,738.4	-4.494	34	.000
	After	148,727.4	192,481.2			
Central	Before	92,690.9	47,016.5	-2.445	10	.035
	After	156,827.3	121,198.4			
East-Coast	Before	27,544.5	49,127.4	-3.143	156	.002
	After	41,247.1	67,034.1			
Southern	Before	31,943.3	35,548.1	-5.774	29	.000
	After	243,160.0	197,110.2			

Studies conducted by Young et al. (2014) found that adopting innovation in forage technology has a significant impact on cattle farmers in Cambodia. Adopting innovation enabled them to expand farm enterprises, do off-farm jobs and improve school attendance. Furthermore, they also generated more income and improved their standard of living. This finding is also supported by Ashley et al. (2018) mentioning that adopting innovation has reduced the labour burden on women and children. It has also potentially increased the household income from the forage establishment and supported the recommendations of forage technology as one of the strategies to boost the financial status among cattle farmers in Cambodia.

As been seen in Table 4.18, the southern region is the most profitable among the four regions, followed by central, northern and east-coast regions, respectively. Hence, these findings will hopefully improve the beef production and the socio-economic

status of beef cattle farmers in Peninsular Malaysia. It can also reveal that adopting innovation has benefited the farmers as their productivity and farm profit have improved.

4.6 Factors Influence the Adoption of Innovation in Beef Cattle Farming

Objective four: To analyse factors that influence the adoption of innovation in beef cattle farming.

Seven independent variables were measured to examine the relationship between the adoption of innovation. The hypothesis and discussion are as below.

1. Age has a significant and negative relationship with the adoption of innovation in beef cattle farming.

Result in Table 4.19 shows that age did not significantly influence the adoption of innovation in beef cattle farming ($p > 0.1$). Several studies also supported that there is no significant relationship between age and adoption of innovation in cattle farming (Baba et al., 2014, 2019; Rathod et al., 2017; Roessali et al., 2011; Wahyudi, 2017). However, in a study by Paul et al. (2017), they mentioned that age is significant and has a negative effect on adopting innovation. The older farmers are reluctant to change from traditional practices since they have long been used to the same routines (Long et al., 2016). Hence, in the context of this study, it is noted that farmers' age does not contribute to innovation adoption among beef cattle farmers due to local conditions, culture and practice (Kiptot & Franzel, 2015).

Table 4.19
Ordinal logistic regression analysis

Predictors	Coefficient	SE	*p*-value	Significance level
Age	-0.007	0.017	0.688	NS
Experience	-0.022	0.018	0.219	NS
Education level	1.257	1.016	0.216	NS
Herd size	0.030	0.018	0.087	*
Government extension	-0.325	0.525	0.536	NS
Farmer-to-farmer extension	2.609	0.808	0.010	***
Access to information	-6.504	1.154	0.000	***

Pseudo R^2: Nagelkarke = 0.614
Notes: *p*-value ≤ 0.1*; *p*-value ≤ 0.05**; *p*-value ≤ 0.01***; not significant ^{NS}

2. Experience has a significant and negative relationship towards adopting innovation in beef cattle farming.

This study found that experience was insignificant ($p > 0.1$) towards adopting innovation in beef cattle farming. This finding is parallel with studies conducted by Baba et al. (2019) and Wahyudi (2017), stating that years of experience among farmers did not influence the adoption of innovation in beef cattle farming. The hypothesis was rejected as there was no significant relationship between experience and innovation adoption in beef cattle farming. In contrast, other scholar have found that farmers' experience in farming activity would affect their attitude in adopting innovations (Ajewole, 2010; Bamire et al., 2002; Paul et al., 2017). Young farmers who lack experience, skills and practice will tend to adopt innovation than the older farmers, while the older farmer who had more fabulous experiences find it hard for them to deviate from the traditional farming system due to the difficulty of adapting to the new changes (Paul et al., 2017). In the Malaysian context, experience does not influence farmers in adopting innovation in beef cattle farming.

3. Education level has a significant and positive relationship towards adopting innovation in beef cattle farming.

The finding from this study stated that education level was not significant ($p > 0.1$) on the adoption of innovation in beef cattle farming. This finding aligns with Baba et al. (2019), showing no significant relationship between education and adopting innovation. This finding is due to the local situation and practice where farmers with any educational background may have had employed innovation on their farms. At the same time, higher knowledge, skills and practice in cattle management is essential to ensure better farm production. Besides, it requires high commitment and courage among the farmer to try on the specific innovation. Meanwhile, other scholars stated that education level is significant towards adopting innovation specifically in cattle farming (Paul et al., 2017; Rathod et al., 2017; Roessali et al., 2011; Wahyudi, 2017). As the farmers have a higher education background, they are more aware of the advantages of adopting innovation, which may ease the farming tasks. Thus, the hypothesis was rejected, proving that the level of education is not a contributing factor towards adopting innovation.

4. The herd size has a significant and positive relationship towards adopting innovation in beef cattle farming.

The herd size was also found to be significant ($p < 0.01$) on the innovation adoption. This result is similar to studies conducted by Baba et al. (2019), Rathod et al. (2017) and Wahyudi (2017), where the number of cattle has made the farmers adopt crop residual as cattle feed, as well as adopting AI and biogas technology. The positive

coefficient showed that farmers were interested in adopting advanced technologies as the information regarding innovation is well-disseminate. Rice and corn straws are two crop residue alternatives to meet the Maros District's cattle feed demand (Baba et al., 2019). Meanwhile, in Pasuruan District, Indonesia, they had the availability of feed for livestock as the integration programs between livestock and crop had overcome the issues of limited cattle feed as well as securing the issues in food security (Parmawati et al., 2018).

5. Government extension service has a significant and positive relationship towards adopting innovation in beef cattle farming.

The DVS's extension services were reported as insignificant ($p > 0.1$) towards adopting innovation in beef cattle farming. This result is in line with studies conducted by Baba et al. (2014) stating that extension intensity by the government does not influence the rate of adoption in intensive rearing, while Suvedi et al. (2017) stated that the extension system would not be properly functioning if there are limited innovative activities and ineffective communication between farmers and extension workers. Moreover, Lestari et al. (2019) mentioned that about 70.14% of farmers in South Sulawesi Province also agreed that the government extension does not sufficiently support the extension program in implementing biosecurity at the farm. However, the finding of this study was contradicted with Baba et al. (2019) since the government's extension services have influenced farmers to adopt crop residue as a feed. Folefack (2015) and Paul et al. (2017) added that a good relationship with extension centres would benefit farmers by gaining information on compost quality and substantially impacting adoption probability.

Based on the observation during the data collection, most farmers need guidance in adopting innovations such as cattle feed and compost use, and the DVS should share these kinds of successful innovations with those farmers. Some farmers also need assistance on cattle breeds to expand their business. Strong chains between farmers, suppliers and wholesalers are essential for the development of the beef cattle sub-sector.

6. Farmer-to-farmer extension has a significant and positive relationship towards adopting innovation in beef cattle farming.

The finding showed that farmer-to-farmer extension was significant ($p < 0.05$) towards adopting innovation in beef cattle farming. This finding is similar to studies conducted by the previous researchers on adopting intensive rearing, feed on crop residual and compost use (Baba et al., 2014, 2019; Paul et al., 2017). Strong membership in a farmer's association will also positively impact the probability of adopting innovation (Paul et al., 2017). This type of extension service was found interesting as the local farmers were attracted to adopt the introduced innovation in cattle farming due to their proficiency in the culture and practices, besides the trust gained from other farmers (Kiptot et al., 2016). Furthermore, the main committee of the farmers' association tended to act as the best example for the other beef cattle farmers and tried to put themselves as a trusted people within their social system (Heong et al., 2002). On the other side, the NGO has gained popularity in extension services, but maintaining the quality of the services poses a big challenge (Suvedi & Ghimire, 2015).

7. Access to information has a significant and positive relationship towards adopting innovation in beef cattle farming.

Based on the results, access to information was significant ($p < 0.01$) towards adopting innovation in beef cattle farming. A strong relationship with extension agents, farmers' associations and research centres led to easy access to information (Luo et al., 2014; Marra et al., 2003). Paul et al. (2017) found that access to information is significant towards adopting innovation and had a similar finding with Folefack (2015) that disseminating information will be well disseminated if research centres and extension workers collaborate and reach farmers to separate the knowledge. Meanwhile, the negative coefficient in this study shows that even though the access to information is good, the adoption rate among cattle farmers is getting lower. This situation is might due to low awareness on the benefits of adopting innovation as well as the financial limitation among certain farmers. On the other hand, finding by Rathod et al. (2017) among farmers in India contradicted this study as well as Folefack (2015) and Paul et al. (2017), where the information sources among cattle farmers in India were not significant towards the adoption of innovation.

CHAPTER 5

SUMMARY AND POLICY RECOMMENDATIONS

Specifically, the main objective of this study was to identify the factors influencing the adoption of innovation in beef cattle farming as well as to examine the profitability and efficiency of innovation introduced. As for this study, the researcher decided to employ the survey method. The target respondents were beef cattle farmers in four regions of Peninsular Malaysia, respectively. A total of 233 respondents were randomly selected and the data were collected through questionnaires. Besides, the study's limitations, policy implications, and suggestions for future research have also been elaborated in this chapter.

5.1 Introduction

Discovering factors that influence the adoption of innovation in beef cattle farming is the main objective of this study. This chapter summarises and concludes the findings besides recommending the relevant strategies to improve the existing policy, which involves all stakeholders including policymakers and the players in this sector. This effort is to ensure the success of the planned programs among beef cattle farmers, specifically. Hence, the explanation for each objective and the findings is essential to discuss the implication of this study.

5.2 Summary

The main objective of this study was to examine the determinants that influence beef cattle farmers to adopt innovation in cattle farming activity at Peninsular Malaysia. The study was designed; (1) to identify the socio-economic status of beef cattle farmers in Peninsular Malaysia; (2) to examine the profitability and efficiency in beef cattle farming by region, herd size and types of innovation; (3) to examine the economic implications of innovation adoption in beef cattle farming in terms of farm performance; and lastly (4) to analyse factors that influence the adoption of innovation in beef cattle farming.

Previous studies in beef cattle farming have mentioned several issues, including the roles of institutions in extension service, the existing policy of food security as well as the deals with Utility Theory on the profitability and effectiveness by adopting innovation. These issues are crucial as adopting innovation at the farm may cause a high cost of production and productivity to fulfil the population's demand.

The understanding of the government extension and farmer-to-farmer extension is different. Farmers preferred farmer-to-farmer extension due to the trust and belief of the local community. Meanwhile, the insufficient supply of beef has also become a threat to food security as it fails to meet the demand of the population. Furthermore, even though the innovations introduced were costly, they were seemed beneficial for the farmers and will bring higher productivity with a good profit return.

The independent variables used in this study were adapted from the related studies and theories that have been reviewed. The model used was the extension of the existing studies to examine the profitability and effectiveness of the innovation with the additional variable adapted from Kiptot & Franzel (2015).

This study has formulated a conceptual model of adoption of innovation integrating the Utility Theory and Diffusion of Innovation Theory to meet its objectives. The dependent variable of the model was the adoption of innovation in beef cattle farming.

Estimating the profitability and efficiency has been done by generating the model and undergoing financial analyses according to the economic theory. The independent variables included the individual and farm characteristics such as age, experience, education level and herd size. The model adapted from Diffusion of Innovation Theory included government extension, farmer-to-farmer extension and access to information. Finally, the impact of innovation in beef cattle farming has been also examined as it is crucial to measure farm performance.

The data collection process was conducted using a structured questionnaire comprising five parts, including the socio-economics and farm profile of the respondents. Besides, financial information was also gathered to examine the profitability and efficiency of the farm activity. Face-to-face interviews with 233 beef cattle farmers were carried out using a disproportionate stratified random sampling basis. Firstly, the beef cattle farmers were stratified according to the four states in Peninsular Malaysia: Kedah, Selangor, Kelantan and Johor, representing northern, central, east coast and southern

regions. Then, the samples of each stratum were drawn using simple random sampling. An economic model of adopting innovation using logistic regression was estimated.

Based on the finding, the mean age of the farmers was 48 years old, and they are still doing this job to fulfil the population's demand. The sad part was that the youths were still doubtful, and some were not interested in jumping into the beef cattle farming business. It is crucial to have more younger farmers as our nation needs to have more backups to overcome the issues in food security and reduce the import of beef from outside.

On the other hand, most of them received their education until *Sijil Pelajaran Malaysia* (SPM) level. Perhaps with a better education background, the youths will be more open-minded and ready to accept changes in practice and have a passion for generating higher income from this activity. As many as 224 of the farmers were male, with 218 micro-scale farmers. They have had 13 years of experience, which is considered mature in this sector and tend to adopt the innovation introduced by the DVS (Department of Veterinary Services) as the mean distance from farm to DVS is only 12.4 km. Meanwhile, the size of the farm is moderately 3.5 acres as some of them owned a palm oil plantation and integrated with the beef cattle. This practice is widely used by today's beef cattle farmers to reduce the use of pesticides and the spending on cattle's feed. Besides, processing compost as a fertiliser and producing silage from corn straws can also improve farmers' living standards.

Furthermore, the cost of farming and total revenue was significant in adopting innovation in beef cattle farming. An increase in the cost of farming will increase the number of cattle and the total revenue when the beef cattle farmers adopt the

innovation. The median profit of all farmers before adopting innovation was RM 18,000, and after the adoption of innovation, it increased to RM 34,080. At the same time, the total cost, total revenue and profit also have a significant difference in adopting innovation. There was a difference in the mean for before and after adopting innovation. Hence, innovation has demonstrated changes in terms of farm performance. Finally, several factors such as herd size, farmer-to-farmer extension and access to information were identified as significant towards adopting innovation. However, farmers' age, experience, education and government extension were not significant in explaining farmers' adoption of innovation.

5.3 Conclusion

The uncertain climate and inefficient farming practices have been noticed as one of the challenges in producing a sufficient beef supply. Hence, innovation in beef cattle farming is needed to improve the existing challenges and produce a greater supply of local beef in the future.

Based on the first objective, to identify the socio-economics profile of beef cattle farmers in Peninsular Malaysia, it can be described as most farmers had secondary school education with a mean age of 48 years old. Besides, most beef cattle farmers had a good experience in beef cattle farming as most of them have had 13 years of experience in this activity. Meanwhile, the average distance is about 12.4 kilometres (km), which is considered acceptable because farmers tend to refuse to adopt an innovation if the distance is too far from the DVS or any veterinary extension centre. On the other hand, most beef cattle farmers owned about 3.5 acres of land, with an

average of 23 cattle on their farm, and they had spent about four hours daily for their farming activity. Hence, based on this finding, it can be concluded that Malaysia still needs younger generations to venture into this sector to reduce the dependency on imported beef in the future.

The second objective is to examine the profitability and efficiency in beef cattle farming by region, herd size, and types of innovation. It is noted that the southern region showed the highest profit percentage changes due to the strategic location of the Malaysian Veterinary Institute in Kluang, Johor, as one of the stop centres for knowledge and skills distribution among beef cattle farmers around Johor. Meanwhile, the percentage changes for the herd size showed that farmers who hold equal or less than 50 cattle are the highest with 34.7% compared to those with greater herd size. It means that as the herd size increases, it does not confirm that the profit will highly increase. Finally, the integration rearing technique emerged with 67% of profit changes as it is a resource-saving practice. Hence, it can be concluded that the location, management of the farm and the right selection of innovation could enhance the farm productivity, reduce the feed cost, and ensure the environmental sustainability.

Furthermore, the third objective is to examine the economic implications of innovation adoption in beef cattle farming in terms of farm performance. It found a significant difference in farming costs before and after adopting innovation. This finding demonstrates that cost affects innovation adoption as it increases when beef cattle farmers adopt such innovations. Meanwhile, there is also a significant difference in the total revenue and profit for before and after adopting innovation in beef cattle farming.

In conclusion, the total cost, revenue and profit increase parallelly as the farmers employ the innovation to benefit their farm and improve the productivity.

Finally, the last objective is to analyse factors influencing innovation adoption in beef cattle farming. The findings state that herd size, farmer-to-farmer extension and access to information had influenced farmers to adopt innovation in beef cattle farming. The number of cattle has made the farmers adopt innovations such as crop residual as cattle feed and silage as feed alternatives during the drought or flood season. Meanwhile, the farmer-to-farmer extension was an interesting extension system where the local farmers were attracted to adopt innovation in cattle farming due to their leaders' proficiency in the culture and practices, besides the trust gained from other farmers. Finally, the dissemination process of skills and knowledge becomes more effective if research centres and extension workers collaborate well with the local farmers.

Hence, based on the findings, perhaps all stakeholders, including the government and private agencies, the policymakers and the farmers, will discuss what is lacking in this sector and introduce the relevant innovations that will benefit the farmers. Doing this could help each other to produce greater beef supply for the Malaysian population and not depend on the imports.

5.4 Policy Recommendations

The concern about adopting innovation in beef cattle farming has long been abandoned. Many parties are not seriously focused on what has been started as this effort needs a good collaboration from all stakeholders, including the farmers. The

shift to an improved agricultural practice is highly anticipated where farmers must be skilled and knowledgeable about the innovation. Efforts must be made to reduce the dependency on import beef, increase employment among youths and create an entrepreneurial mindset among farmers by processing the compost and producing feed from the crop waste to generate more income. The suggestions for policy implications based on the findings of this study are stated as below:

5.4.1 The implementation of the extension programs must be suited to the needs of the farmers

As discussed in the discussion part, not all farmers can adopt innovation due to limitations such as budget constraints, less self-awareness and not being ready to accept the new changes. Extension agents from the government agencies and farmer's associations must realise this situation and know what the farmers need in their farming activity. As an example, due to the increasing price of animal feed, the extension agents can deliver their knowledge and skills on making silage as the stock during drought and flood season. On the other hand, planting Napier as the feed source is also essential to ensure that the farmers can reduce the feed cost and produce it by themselves.

5.4.2 The regular meetings between the extension agents and beef cattle farmers

Communication between extension agents, either from the government agencies or farmers' associations, is vital to ensure the success of a program and increase the local beef supply. Extension agents must understand and be highly skilled in a particular innovation before being transferred to the farmers. They have to also spread the awareness of adopting innovation and the advantages of the latest practices for future use. A proper method and skills with additional knowledge and awareness can ensure that a farmer has more confidence in adopting innovation. However, extension agents must also have regular site visits to the farms of those farmers who have a low understanding of the innovation. Hence, the community will get more trust in the extension service and improve beef cattle production.

5.4.3 The information access on innovation and the market linkage

The information regarding the innovation and market linkage is crucial among farmers. Some farmers have mentioned that they had difficulty receiving information on the current innovation as well as selling their beef cattle. The usage of smartphones among farmers has become necessary nowadays. However, a few farmers are still not ready to have a smartphone even though they are affordable to have it, especially the older farmers. The information dissemination regarding the current practice and dealing procedure with the customers is commonly done through the social media applications such as WhatsApp and Facebook. The advanced farmers are now exploring TikTok to get the engagement among local people about their business and to disseminate

information about the management of beef cattle. In the meantime, they have done two tasks, sharing the information about beef cattle management and selling their beef cattle among the local community. Thus, the importance of information access through modern ways can improve beef production as well as farm performance.

Thus, several recommendations suggested in this study can help this sector to move forward in the future. Firstly, the agricultural program launched by the DVS must meet the farmers' needs. It ensures they can adopt it without any hassles and improve their livelihood as well. On the other hand, range feeding methods should also be avoided as this practice would harm the road users and may cause an accident. Besides, those cattle will also potentially damage other farmers' crops. Instead of not a proper rearing method, it also may troublesome the villagers, farmers and road users.

The scheduled meeting between DVS and farmers is essential to ensure well-distributed knowledge and skills. It must also include hands-on training and solutions to the problems that occurred among the community of farmers. Lastly, good networking between farmers and multinational companies is essential to collaborate to produce high-quality feed and maintain healthy cattle. Hence, a win-win situation will occur among the farmers and the company.

5.5 Limitations of Study

This study discovered the influencing factors among beef cattle farmers to adopt innovation and evaluate the innovation's output. However, this study only covered four (4) states of Peninsular Malaysia: Kedah, Selangor, Kelantan and Johor, but did

not generalise to other states, including Sabah and Sarawak. The respondents of this study were also limited to beef cattle farmers and did not include the other ruminant farmers such as buffalo, sheep and goat. Besides, conducting the longitudinal study was also not applicable in this study as it is time-consuming, and the researcher did not secure any research grants.

5.6 Future Recommendations

This study has explained factors influencing innovation adoption among beef cattle farmers in Peninsular Malaysia. It was noted that several innovations are still new and that farmers are not ready to adopt them onto their farms. However, comprehensive research and observation among academics and experts are needed to ensure that innovation in beef cattle farming can be continuously introduced among farmers.

It is also suggested that a longitudinal study is conducted for the Long Term Research Grant Scheme (LRGS) to evaluate the actual situation before and after implementing a particular innovation. A qualitative study would also be relevant as it can dig more input from the beef cattle farmers and find the real problems from the Focus Group Discussion (FGD).

REFERENCES

Abdulla, I., Mohamed Arshad, F., Bala, B. K., Bach, N. L., & Mohammadi, S. (2016). Management of beef cattle production in Malaysia: A step forward to sustainability. *American Journal of Applied Sciences*, *13*(9), 976–983. https://doi.org/10.3844/ajassp.2016.976.983

Adeogun, O. A., Ajana, A. M., Ayinla, O. A., Yarhere, M. T., & Adeogun, M. O. (2008). Application of Logit Model in Adoption Decision : A Study of Hybrid Clarias in Lagos State, Nigeria. *American-Eurasian J. Agric. & Environ. Sci*, *4*(4), 468–472.

Ahmad Shaharudin, A. A., & Tumin, S. A. (2019). A Brief on 'Beef.' *Khazanah Research Institute*, 1–18.

Ajewole, O. C. (2010). Farmer's response to adoption of commercially available organic fertilizers in Oyo state, Nigeria. *African Journal of Agricultural Research*.

Ali, J. (2004). *Impact of Enforcement and Co-Management Activity on Compliance Behavior of Fishermen in Peninsular Malaysia*. Universiti Utara Malaysia.

Allahyari, M. S. (2009). Agricultural sustainability : Implications for extension systems. *African Journal of Agricultural Research*, *4*(9), 781–786.

Ariff, O. M., Sharifah, N. Y., & Hafidz, A. W. (2015). Status of beef industry of Malaysia. *Malaysian Journal of Animal Science*, *18*(2), 1–21.

http://agris.upm.edu.my:8080/dspace/handle/0/13994

Ashley, K., Young, J. R., Kea, P., Suon, S., Windsor, P. A., & Bush, R. D. (2018). Socioeconomic impact of forage-technology adoption by smallholder cattle farmers in Cambodia. *Animal Production Science*, *58*, 393–402. https://doi.org/dx.doi.org/10.1071/AN16164

Ayele, S., Duncan, A., Larbi, A., & Khanh, T. T. (2012). Enhancing innovation in livestock value chains through networks: Lessons from fodder innovation case studies in developing countries. *Science and Public Policy*, *39*(3), 333–346. https://doi.org/10.1093/scipol/scs022

Baba, S., Dagong, M. I. A., & Risal, M. (2014). Some factors affecting intensive rearing adoption on beef cattle farmers in Wajo regency, South Sulawesi Province. *Journal of the Indonesian Tropical Animal Agriculture*, *39*(4), 235–241. https://doi.org/10.14710/jitaa.39.4.235-241

Baba, S., Dagong, M. I. A., Sohrah, S., & Utamy, R. F. (2019). Factors affecting the adoption of agricultural by-products as feed by beef cattle farmers in Maros regency of South Sulawesi, Indonesia. *Tropical Animal Science Journal*, *42*(1), 76–80. https://doi.org/10.5398/tasj.2019.42.1.76

Bamire, A. S., Fabiyi, Y. L., & Manyong, V. M. (2002). Adoption pattern of fertiliser technology among farmers in the ecological zones of south-western Nigeria: A Tobit analysis. In *Australian Journal of Agricultural Research*. https://doi.org/10.1071/AR01095

Basunathe, V. K., Sawarkar, S. W., & Sasidhar, P. V. K. (2010). Adoption of dairy production technologies and implications for dairy development in India. *Outlook*

on Agriculture, *39*(2), 134–140. https://doi.org/10.5367/000000010791745385

Battles, R. W., & Robert C. Thompson, J. (2000). *Fundamentals of Agribusiness Finance*. Iowa State University Press: Ames, IA.

Benyamin, L. (2019). Research and technology development in Southeast Asian economies are drifting away from agriculture and farmers' needs. *Journal of Science and Technology Policy Management*, *15*(1), 98–115. https://doi.org/doi.org/10.1108/14626000610665944

Bernard, T., & Spielman, D. J. (2009). Reaching the rural poor through rural producer organizations? A study of agricultural marketing cooperatives in Ethiopia. *Food Policy*, *34*(1), 60–69. https://doi.org/10.1016/j.foodpol.2008.08.001

Blazy, J. M., Barlagne, C., & Sierra, J. (2015). Environmental and economic impacts of agri-environmental schemes designed in French West Indies to enhance soil C sequestration and reduce pollution risks. A modelling approach. *Agricultural Systems*, *140*, 11–18. https://doi.org/10.1016/j.agsy.2015.08.009

Boahene, K., Snijders, T. A. B., & Folmer, H. (1999). An Integrated Socioeconomic Analysis of Innovation Adoption : The Case of Hybrid Cocoa in Ghana. *Journal of Policy Modeling*, *21*(2), 167–184.

Burton, R. J. F. (2004). Reconceptualising the "behavioural approach" in agricultural studies: A socio-psychological perspective. *Journal of Rural Studies*. https://doi.org/10.1016/j.jrurstud.2003.12.001

Chang, J., Lieu, P., Liang, J., Liu, H., & Wong, S. (2011). Factors influencing technology acceptance decisions. *African Journal of Business Management*.

Creswell, J. (2003). *Research Design: Qualitative, Quantitative and Mixed Method Approaches* (5th ed.). SAGE Publications Inc. https://doi.org/10.3109/08941939.2012.723954

D'Emden, F. H., Llewellyn, R. S., & Burton, M. P. (2008). Factors influencing adoption of conservation tillage in Australian cropping regions. *Australian Journal of Agricultural and Resource Economics*. https://doi.org/10.1111/j.1467-8489.2008.00409.x

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319–340.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science*, *35*(8), 982–1003. https://doi.org/10.1287/mnsc.35.8.982

Davis, K. E. (2008). Extension in Sub-Saharan Africa: Overview and Assessment of Past and Current Models, and Future Prospects. *Journal of International Agricultural and Extension Education*, *15*(3), 15–28.

de Janvry, A., Fafchamps, M., & Sadoulet, E. (1991). Peasant Household Behaviour with Missing Markets: Some Paradoxes Explained. *The Economic Journal*. https://doi.org/10.2307/2234892

Department of Statistics Malaysia. (2019). *Selected Agricultural Indicators 2019*.

Department of Statistics Malaysia. (2021). *Press Release Supply and Utilization Accounts Selected Agricultural Commodities, Malaysia 2016-2020*. https://www.dosm.gov.my

Department of Veterinary Services. (2017). *The Total of Beef Cattle Farmers in Malaysia*.

Dikko, M. (2016). Establishing construct validity and reliability: Pilot testing of a qualitative interview for research in takaful (Islamic insurance). *Qualitative Report*, *21*(3).

Drummond, A. (2017). Feasibility and pilot studies: Why are they important? *British Journal of Occupational Therapy*, *80*(6), 335–336. https://doi.org/10.1177/0308022617697743

Duflo, E., Kremer, M., & Robinson, J. (2008). How High Are Rates of Return to Fertilizer? Evidence from Field Experiments in Kenya. *American Economic Review*. https://doi.org/10.1257/aer.98.2.482

Edwards, W. (1954). The theory of decision making. *Psychological Bulletin*. https://doi.org/10.1037/h0053870

Elias, A., Nohmi, M., Yasunobu, K., & Ishida, A. (2013). Effect of Agricultural Extension Program on Smallholders' Farm Productivity: Evidence from Three Peasant Associations in the Highlands of Ethiopia. *Journal of Agricultural Science*, *5*(8), 163–181. https://doi.org/10.5539/jas.v5n8p163

Feder, G., Just, R., & Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change*, *33*(2), 255–298. https://doi.org/10.1086/451461

Feder, G., & Umali, D. L. (1993). The adoption of agricultural innovations. A review. *Technological Forecasting and Social Change*, *43*, 215–239.

https://doi.org/10.1016/0040-1625(93)90053-A

Folefack, A. J. J. (2015). The Rural Exodus of Young Farmers and its Impact on the Shortage of Labor and Food Crop Production in Cameroon: A Computable General Equilibrium Model's Analysis. *Journal of Human Ecology*. https://doi.org/10.1080/09709274.2015.11906838

Goswami, K., Choudhury, H. K., & Saikia, J. (2012). Factors influencing farmers' adoption of slash and burn agriculture in North East India. *Forest Policy and Economics*. https://doi.org/10.1016/j.forpol.2011.11.005

Government of Malaysia. (2006). Ninth Malaysia Plan (2006-2010). In *Economic Planning Unit, Prime Minister's Department*.

Hair, J. F. (2015). Essentials of Business Research Methods. In *Essentials of Business Research Methods*. https://doi.org/10.4324/9781315704562

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). Multivariate data analysis with readings. In *Prentice-Hall, Upper Saddle River* (4th ed.). Pearson College.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). Exploratory Data Analysis in Business and Economics. In *Univariate Data Analysis* (pp. 23–60). Springer International Publishing.

Halim, R. A., Shampazuraini, S., & Idris, A. B. (2013). Yield and nutritive quality of nine napier grass varietas in Malaysia. *Malaysian Society Animal Production*, *16*(2), 37–44.

Hartono, B., Hariyono, M. B., & Rochman, F. (2005). Goat Raising as Source of the

Household‘s Farming Income and Absorption of the Family ‘ s Labor Alternativ : Study at Tamansari Ampelgading Malang Regency East Java. *Journal Indonesian Tropical Animal Agriculture*, *31*(2), 99–104.

Haryani, H., Norlindawati, A. P., Norfadzrin, F., Aswanimiyuni, A., & Azman, A. (2018). Yield and nutritive values of six napier (Pennisetum purpureum) cultivars at different cutting age. *Malaysian Journal of Veterinary Research*, *9*(2), 6–12.

Haryanto, A., Cahyani, D., Triyono, S., Murdapa, F., & Haryono, D. (2017). Economic benefit and greenhouse gas emission reduction potential of a family-scale cowdung anaerobic biogas digester. *International Journal of Renewable Energy Development*, *6*(1), 29–36. https://doi.org/10.14710/ijred.6.1.29-36

Hashim, F. A. H. (2015). Strategies to strengthen livestock industry in Malaysia. *Malaysian Agricultural Research and Development Institute (MARDI)*, 1–6. https://doi.org/10.1007/s11578-004-0030-8

Heong, K. L., Escalada, M. M., Sengsoulivong, V., & Schiller, J. (2002). Insect management beliefs and practices of rice farmers in Laos. *Agriculture, Ecosystems and Environment*. https://doi.org/10.1016/S0167-8809(01)00304-8

Hussin, F., Ali, J., & Noor, M. S. Z. (2014). *Kaedah Penyelidikan dan Analisis Data SPSS*. Universiti Utara Malaysia.

Israel, G. D. (1992). Sampling the Evidence of Extension Program Impact. *IFAS Extension, University of Florida.*, *PEOD5*, 1–5.

Jaleta, M., Gebremedhin, B., Tegegne, A., Jemaneh, S., Lemma, T., & Hoekstra, D. (2013). Evolution of input supply and service hubs in dairy development at Ada’a

milk shed in Ethiopia. *Development in Practice*, *23*(2), 249–263. https://doi.org/10.1080/09614524.2013.772119

Jamaludin, M. H., Hassan, M. H., Amin, M. R., & Zulhisyam, A. K. (2014). The Future of the Malaysian Beef Industry. In *J. Trop. Resour. Sustain. Sci* (Vol. 2). https://doi.org/10.1111/een.12026

Johari, J. a., & Jasmi, Y. (2009). Breeds and Breeding Program for Beef Production in Malaysia. *Proceedings of the 8th Malaysia Congress on Genetics*.

Johnson, R. A., & Wichern, D. V. (2007). Applied multivariate statistical analysis. In *Pearson Education Publications*. Englewood Cliffs, N.J. : Prentice-Hall.

Kamarul Zaman, N. B. (2018). *Penentu penerimaan petani dalam inovasi penanaman padi melaui kaedah projek estet padi dan sistem intensifikasi padi*. Universiti Utara Malaysia.

Kay, R. D., Edwards, W. M., & Duffy, P. A. (2016). *Farm Management* (8th ed.). McGraw Hill.

Kebebe, E. (2019). Bridging technology adoption gaps in livestock sector in Ethiopia: A innovation system perspective. *Technology in Society*, *57*, 30–37. https://doi.org/10.1016/j.techsoc.2018.12.002

Kiptot, E., & Franzel, S. (2015). Farmer-to-farmer extension: opportunities for enhancing performance of volunteer farmer trainers in Kenya. *Development in Practice*, *25*(4), 503–517. https://doi.org/10.1080/09614524.2015.1029438

Kiptot, E., Karuhanga, M., Franzel, S., & Benjamin, P. (2016). *Volunteer farmer-trainer motivations in East Africa : practical implications for enhancing farmer-*

to-farmer extension. *14*(3), 339–356. https://doi.org/10.1080/14735903.2015.1137685

Kusriatoni, Oktaviani, R., Syaukat, Y., & Said, A. (2014). Analysis of the effects of beef import restrictions policy on beef self-sufficiency in Indonesia. *Journal of the International Society for Southeast Asian Agricultural Sciences*, *20*(1), 115–130.

Lestari, V. S., Rahardja, D. P., Mappigau, P., Rohani, S. T., & Sirajuddin, S. N. (2019). Beef cattle farmers behavior toward biosecurity. *Journal of the Indonesian Tropical Animal Agriculture*, *44*(60), 204–212. https://doi.org/10.14710/jitaa.44.2.204-212

Long, T. B., Blok, V., & Coninx, I. (2016). Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: Evidence from the Netherlands, France, Switzerland and Italy. *Journal of Cleaner Production*, *112*(Part 1), 9–21. https://doi.org/10.1016/j.jclepro.2015.06.044

Luo, L., Wang, Y., & Qin, L. (2014). Incentives for promoting agricultural clean production technologies in China. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2014.03.045

Manner, M., & Gowdy, J. (2010). The evolution of social and moral behavior: Evolutionary insights for public policy. *Ecological Economics*. https://doi.org/10.1016/j.ecolecon.2008.04.021

Marra, M., Pannell, D. J., & Abadi Ghadim, A. (2003). The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: Where are we on the learning curve? *Agricultural Systems*.

https://doi.org/10.1016/S0308-521X(02)00066-5

Maxwell, T. W., Songly, Y., Ung, B., Peou, L., & Reid, J. (2012). The social and other impacts of a cattle/crop innovation in Cambodia. *Agricultural Systems*, *107*, 83–91. https://doi.org/10.1016/j.agsy.2011.10.008

Md. Said, M. F., & Man, N. (2014). Evaluation of Target Area Concentration (TAC) Programme in Malaysia's Integrated Cattle and Oil Palm Farming. *Journal of Food Products Marketing*, *20*(November), 151–163. https://doi.org/10.1080/10454446.2014.921870

Ministry of Agriculture and Agro-Based Industry. (2011). *Dasar Agromakanan Negara (2011-2020)*.

Mohamad Termezai, N. F. (2019). *The Acceptance of Fish Cracker Processing Technology among Fish Cracker Entrepreneurs in East Coast of Peninsular Malaysia*. Universiti Malaysia Kelantan.

Mohamad Termezai, N. F., Abdullah, F. A., Jamaludin, M. H., & Che Harun, H. (2017). Technology Acceptance Level among Fish Cracker's Entrepreneurs in East Coast Economic Region (ECER). *The Social Sciences*, *12*(12), 2321–2325.

Mortimer, G., Neale, L., Hasan, S. F. E., & Dunphy, B. (2015). Investigating the factors influencing the adoption of m-banking: A cross cultural study. *Marketing Intelligence and Planning*. https://doi.org/10.1108/IJBM-07-2014-0100

Mudzengi, C. P., Taderera, L. M., Tigere, A., Kapembeza, C. S., Moyana, S., Zimondi, M., Derembwe, E. T., & Dahwa, E. (2014). Adoption of urea treatment of maize stover technology for dry season supplementation of cattle in Wedza, Zimbabwe.

Livestock Research for Rural Development, *26*(9), 1–8.

Musa, M., Ismail, M. M., & Ismail, W. A. N. I. (2019). Effectiveness of Extension Agent Services in Influencing the Adoption of Modern Hive in Sustainable Stingless Beekeeping. *Journal of Sustainability Science and Management*, *14*(4), 14–24.

Mzoughi, N. (2014). Do organic farmers feel happier than conventional ones? An exploratory analysis. *Ecological Economics*. https://doi.org/10.1016/j.ecolecon.2014.04.015

Naseem, A., Spielman, D. J., & Omamo, S. W. (2010). Private-sector investment in R&D: A review of policy options to promote its growth in developing-country agriculture. *Agribusiness*. https://doi.org/10.1002/agr.20221

Odendo, M., Obare, G., & Salasya, B. (2009). Factors responsible for differences in uptake of integrated soil fertility management practices amongst smallholders in western Kenya. *African Journal of Agricultural Research*, *4*(11), 1303–1311.

Ogundari, K., & Bolarinwa, O. D. (2018). Impact of agricultural innovation adoption : a meta-analysis. *Australian Journal of Agricultural and Resource Economics*, *59*, 1–20. https://doi.org/10.1111/1467-8489.12247

Pambudy, R. (2018). The Development of Adopting Innovation on Entrepreneurship Status of Madura Cattle Farmers. *Tropical Animal Science Journal*, *41*(2), 147–156. https://doi.org/10.5398/tasj.2018.41.2.147

Panadi, M., Mohamed, W. Z., Rusli, N. D., & Mat, K. (2018). Effects of medicated and non-medicated multi-nutrient block supplementation on gastrointestinal

parasite infestation and blood hematological parameters of lactating Saanen goats. *Sains Malaysiana*. https://doi.org/10.17576/jsm-2018-4707-12

Paramio, M. T., & Izquierdo, D. (2014). Assisted reproduction technologies in goats. *Small Ruminant Research*. https://doi.org/10.1016/j.smallrumres.2014.01.002

Parmawati, R., Mashudi, Budiarto, A., Suyadi, & Kurnianto, A. S. (2018). Developing sustainable livestock production by feed adequacy map: A case study in Pasuruan, Indonesia. *Tropical Animal Science Journal*, *41*(1), 67–76. https://doi.org/10.5398/tasj.2018.41.1.67

Paul, J., Sierra, J., Causeret, F., Guindé, L., & Blazy, J. M. (2017). Factors affecting the adoption of compost use by farmers in small tropical Caribbean Islands. *Journal of Cleaner Production*, *142*, 1387–1396. https://doi.org/10.1016/j.jclepro.2016.11.168

Phonthanukitithaworn, C., Sellitto, C., & Fong, M. (2015). User intentions to adopt mobile payment services: A study of early adopters in Thailand. *Journal of Internet Banking and Commerce*.

Rahm, M. R., & Huffman, W. E. (1984). The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables. *American Journal of Agricultural Economics*, *66*(4), 405–413. https://doi.org/10.2307/1241669

Rathod, P., Chander, M., & G., C. S. (2017). Adoption status of artificial insemination in Indian dairy sector: Application of multinomial logit model. *Journal of Applied Animal Research*, *45*(1), 442–446. https://doi.org/10.1080/09712119.2016.1208099

Raza, K., Wang, G., Naqvi, S. A. A., & ul Hassan, R. H. (2021). Efficacy of feed improvement in livestock farming to offset climate variations in Punjab, Pakistan: silage as an example. *Environmental Science and Pollution Research*, *28*(28), 37279–37291. https://doi.org/10.1007/s11356-021-13181-5

Reddy, P. P. (2016). Integrated Crop–Livestock Farming Systems. In *Sustainable Intensification of Crop Production* (pp. 357–370). Springer, Singapore. https://doi.org/https://doi.org/10.1007/978-981-10-2702-4_23

Roessali, W., Masyhuri, Nurtini, S., & Darwanto, D. H. (2011). Factors Influencing Farmers' Decision to Increase Beef Cattle Business Scale in Central Java Province. *Journal Indonesian Tropical Animal Agriculture*, *36*(1), 27–35. http://marefateadyan.nashriyat.ir/node/150

Rogers, E. M. (1983). Diffusion of innovations-Third Edition. In *The Free Press, A Division of Macmillan Publishing Co., Inc.* https://doi.org/citeulike-article-id:126680

Rogers, E. M. (1995). *Diffusion of Innovations* (4th ed.). https://doi.org/citeulike-article-id:126680

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press. https://doi.org/10.1111/j.1467-9523.1970.tb00071.x

Roscoe, J. T. (1975). Fundamental research statistics for the behavioural sciences (2nd Edition). In *Holt Rinehart & Winston, New York*.

Sahin, I. (2006). Detailed Review of Rogers' Diffusion of Innovations Theory and Educational Technology-Related Studies Based on Rogers' Theory. *The Turkish*

Online Journal of Educational Technology, *5*(2), 14–23. https://doi.org/10.1287/mnsc.43.7.934

Sekaran, U. (2006). *Research method of business: A skill-building approach*. John Wiley & Sons, Inc.

Serin, T., & Hashim, F. A. H. (2010). Status and demand of technology for selected beef cattle producers in Peninsular Malaysia. *Economic and Technology Management Review*, *5*, 21–26.

Siwar, C., Idris, N. D. M., Yasar, M., & Morshed, G. (2014). Issues and challenges facing rice production and food security in the granary areas in the East Coast Economic Region (ECER), Malaysia. *Research Journal of Applied Sciences, Engineering and Technology*, *7*(4), 711–722. https://doi.org/10.19026/rjaset.7.307

Sotamenou, J., & Parrot, L. (2013). Sustainable urban agriculture and the adoption of composts in Cameroon. *International Journal of Agricultural Sustainability*. https://doi.org/10.1080/14735903.2013.811858

Steenkamp, J.-B. E. M., Jong, M. G. De, & Baumgartner, H. (2010). Socially Desirable Response Tendencies in Survey Research. *Journal of Marketing Research*, *XLVII*(April 2010), 199–214.

Sundaram, J. K., & Zhai Gen, T. (2019). Achieving Food Security for all Malaysians. In *Khazanah Research Institute*.

Supaporn, P., Kobayashi, T., & Supawadee, C. (2013). Factors affecting farmers' decisions on utilization of rice straw compost in Northeastern Thailand. *Journal*

of Agriculture and Rural Development in the Tropics and Subtropics.

Suppadit, T., Phumkokrak, N., & Poungsuk, P. (2006). Adoption of Good Agricultural Practices for Beef Cattle Farming of Beef Cattle - Raising Farmers in Tambon Hindard, Dan Khunthod Distrct, Nakhon Ratchasina Province, Thaland. *Current Applied Science and Technology*, *6*(2), 67–73. https://li01.tci-thaijo.org/index.php/cast/article/view/94027

Suvedi, M., & Ghimire, R. (2015). How Competent Are Agricultural Extension Agents and Extension Educators In Nepal? *Innovation for Agricultural Training and Education, Feed the Future, USAID, Michigan State University. Accessed December*, *15*(December), 2016.

Suvedi, M., Ghimire, R., & Kaplowitz, M. (2017). Farmers' participation in extension programs and technology adoption in rural Nepal: a logistic regression analysis. *Journal of Agricultural Education and Extension*, *23*(4), 351–371. https://doi.org/10.1080/1389224X.2017.1323653

Tabachnick, B. G., & Fidell, L. S. (2019). *Using Multivariate Statistics* (7th ed.). Pearson Education, Inc.

Tanguy, B., Dercon, S., Orkin, K., & Taffesse, A. S. (2014). The Future in Mind: Aspirations and Forward-Looking Behaviour in Rural Ethiopia. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2514590

The World Bank. (2008). Agriculture for Development. In *World Development Report*. https://doi.org/10.1596/978-0-8213-7233-3

Von Neumann, J., & Morgenstern, O. (1947). Theory of games and economic

behavior, 2nd rev. ed. In *Theory of games and economic behavior, 2nd rev. ed.* Princeton University Press.

Wahyudi, J. (2017). The Determinant Factors of Biogas Technology Adoption in Cattle Farming: Evidences from Pati, Indonesia. *Int. Journal of Renewable Energy Development*, *6*(October), 235–240.

Yan Piaw, C. (2006). Kaedah dan Statistik Penyelidikan - Buku 2. In *Mc Graw Hill Education*.

Yao, P., Stephen, C. S., & Sulaiman, M. (2018). Agricultural Extension and Technology Adoption for Food Security: Evidence from Uganda. *American Journal of Agricultural Economics*, *00*(April), 1–20. https://doi.org/10.1093/ajae/aay012

Yimer, N., Muhammad, Sarsaifi, N., Rosnina, Khumran, & And Kaka, A. M. (2015). Effect of honey supplementation into Tris Extender on Cryopreservation of Bull Spermatozoa. *J. Anim. Sci*, *18*(2), 47–54.

Young, J. R., O'Reilly, R. A., Ashley, K., Suon, S., Leoung, I. V., Windsor, P. A., & Bush, R. D. (2014). Impacts on rural livelihoods in cambodia following adoption of best practice health and husbandry interventions by smallholder cattle farmers. *Transboundary and Emerging Diseases*, *61*(SUPPL1.), 11–24. https://doi.org/10.1111/tbed.12193

Zayadi, R. A. (2021). Current Outlook of Livestock Industry in Malaysia and Ways Towards Sustainability. *Journal of Sustainable Natural Resources*, *2*(2), 1–11. http://publisher.uthm.edu.my/ojs/index.php/jsunr

Zulkepli, M., Sipan, I., & Jibril, J. D. (2017). An Exploratory Factor Analysis and Reliability Analysis for Green Affordable Housing Criteria Instrument. *International Journal of Real Estate Studies*, *11*(4), 9–21.

APPENDIX 1A

Questionnaire

KAJIAN PENGGUNAAN INOVASI DALAM PENTERNAKAN LEMBU PEDAGING DI SEMENANJUNG MALAYSIA

Kajian ini bertujuan untuk melihat penilaian ekonomi terhadap aktiviti penternakan lembu pedaging dalam menerimaguna inovasi penternakan. Dapatan daripada kajian ini adalah penting bagi memastikan sekuriti makanan negara terjamin dan penambahbaikkan dasar pertanian negara yang sedia ada.

Oleh itu, pihak kami amat memerlukan kerjasama dan sokongan pihak tuan/puan dalam memberi maklum balas terhadap kajian ini. Segala maklumat yang diberikan akan dirahsiakan dan tujuan pengumpulan data ini adalah untuk kegunaan akademik.

Sekian, terima kasih.

Nama penyelidik:
Farah Adila Abdullah

Penyelia:
Prof. Dr. Jamal Ali
Dr. Mohd Saifoul Zamzuri Noor

Pusat Pengajian Ekonomi, Kewangan dan Perbankan,
Kolej Perniagaan,
Universiti Utara Malaysia

Nama penternak : _____

No. telefon : _____

BAHAGIAN A: PENERIMAGUNAAN INOVASI DALAM TERNAKAN LEMBU

Sila tandakan jawapan anda pada ruang di bawah mengikut skala yang diberikan.

Sangat tidak setuju = 1;
Tidak setuju = 2;
Setuju = 3;
Sangat setuju = 4

Definisi INOVASI:

- Sesuatu **yang baru diperkenalkan** seperti **kaedah, sistem, alat** dan lain-lain yang baru, atau
- Perihal mengadakan, memulakan seusatu yang baru

No.	Pernyataan	Skala			
		1	2	3	4
1.	Saya menerimaguna inovasi untuk penternakan lembu.	1	2	3	4
2.	Saya menerimaguna inovasi untuk meningkatkan produktiviti ladang saya.	1	2	3	4
3.	Saya berpendapat menerimaguna inovasi adalah penting dalam penternakan lembu.	1	2	3	4
4.	Saya mendapat banyak manfaat dengan menerimaguna inovasi dalam penternakan lembu.	1	2	3	4
5.	Saya mengambil tahu inovasi terkini yang diperkenalkan dalam penternakan lembu.	1	2	3	4
6.	Saya berpendapat menerima guna inovasi tidak melibatkan kos yang tinggi.	1	2	3	4
7.	Saya sentiasa terdedah dengan kepentingan menerimaguna inovasi dalam penternakan lembu.	1	2	3	4
8.	Saya berpendapat mengamalkan sistem pengurusan ladang yang lebih baik juga dikira sebagai menerimaguna inovasi.	1	2	3	4

BAHAGIAN B: KEMAHIRAN PENGURUSAN LADANG
Sila tandakan jawapan anda pada ruang di bawah mengikut skala yang diberikan.

Tidak mahir = 1;
Mahir = 2;
Sangat mahir = 3

No.	Pernyataan	Skala		
		1	**2**	**3**
1.	Kemahiran menguruskan pekerja	1	2	3
2.	Kemahiran mengendalikan peralatan ladang	1	2	3
3.	Kemahiran mempraktikkan aspek keusahawanan	1	2	3
4.	Kemahiran dalam penyimpanan rekod	1	2	3
5.	Kemahiran dalam aktiviti pemasaran	1	2	3
6.	Kemahiran penjagaan anak lembu	1	2	3
7.	Kemahiran membersihkan ladang dan kandang	1	2	3
8.	Kemahiran penjagaan kesihatan lembu	1	2	3
9.	Kemahiran penjagaan kebersihan lembu	1	2	3
10.	Kemahiran membiakkan lembu	1	2	3
11.	Kemahiran menjalankan prosedur permanian beradas	1	2	3
12.	Kemahiran menyediakan nutrisi yang baik untuk lembu	1	2	3

BAHAGIAN C: AKSES KEPADA MAKLUMAT

Sila tandakan jawapan anda pada ruang di bawah mengikut skala yang diberikan.

Sangat tidak setuju = 1;
Tidak setuju = 2;
Setuju = 3;
Sangat setuju = 4

No.	Pernyataan	Skala			
		1	**2**	**3**	**4**
1.	Maklumat berkaitan inovasi penternakan mudah diterima oleh penternak.	1	2	3	4
2.	Saluran mendapatkan maklumat berkaitan insentif, latihan dan pemasaran adalah mudah.	1	2	3	4
3.	Ilmu dan teknik baharu yang disampaikan adalah bermanfaat kepada penternak.	1	2	3	4
4.	Saya berpendapat penternak akan menerimaguna inovasi jika maklumat yang disampaikan adalah jelas.	1	2	3	4
5.	Saya berpendapat komunikasi yang berkesan antara agen pengembangan dan penternak adalah penting.	1	2	3	4
6.	Maklumat terkini berkaitan inovasi ternakan lembu mudah diperoleh dari pelbagai sumber.	1	2	3	4
7.	Pihak JPV atau NGO perlu tahu saluran yang tepat untuk menyampaikan maklumat berkaitan inovasi.	1	2	3	4
8.	Pemilihan saluran komunikasi yang tepat membolehkan penternak tertarik untuk menerimaguna inovasi.	1	2	3	4

BAHAGIAN D: MAKLUMAT LADANG Sila nyatakan DAN bulatkan jawapan anda pada ruang yang disediakan.			
1.	Adakah anda mempunyai kawasan ragut?	**YA**	**TIDAK**
2.	Adakah anda mempunyai kemudahan kandang?	**YA**	**TIDAK**
3.	Adakah anda mempunyai kemudahan penimbang lembu di ladang?	**YA**	**TIDAK**
4.	Adakah anda mempunyai kemudahan lori?	**YA**	**TIDAK**
5.	Adakah anda mempunyai BURUH KELUARGA? Jika **YA**, nyatakan bilangan: _____	**YA**	**TIDAK**
6.	Apakah sistem bayaran upah BURUH KELUARGA? a. Gaji harian, RM ____ sehari x ____ hari seminggu b. Gaji bulanan, RM ____ sebulan c. Lain-lain d. Tiada upah		
7.	Adakah anda mempunyai BURUH BUKAN KELUARGA? Jika **YA**, nyatakan bilangan: _____	**YA**	**TIDAK**
8.	Sistem bayaran upah BURUH BUKAN KELUARGA? a. Gaji harian, RM ____ sehari x ____ hari seminggu b. Gaji bulanan, RM ____ sebulan c. Lain-lain d. Tiada upah		
9.	Adakah anda cenderung menerimaguna inovasi setelah menyertai program yang dianjurkan oleh Jabatan Perkhidmatan Veterinar (JPV)?	**YA**	**TIDAK**
10.	Adakah anda cenderung menerimaguna inovasi setelah menyertai program yang dianjurkan oleh rakan-rakan penternak?	**YA**	**TIDAK**
11.	Adakah aktiviti penternakan anda berdaftar dengan Jabatan Perkhidmatan Veterinar (JPV)?	**YA**	**TIDAK**
12.	Berapa kerapkah aktiviti perkongsian mengenai inovasi di tempat anda? _____		

Sila nyatakan DAN bulatkan jawapan anda pada ruang yang disediakan:

	Item	SEBELUM MENERIMAGUNA INOVASI	SELEPAS MENERIMAGUNA INOVASI
14.	Apakah teknik penternakan yang diamalkan SEBELUM dan SELEPAS menerimaguna inovasi?	a. Ragutan lepas bebas b. Integrasi c. Fidlot	a. Ragutan lepas bebas b. Integrasi c. Fidlot
15.	Apakah teknik pembiakan yang diamalkan SEBELUM dan SELEPAS menerimaguna inovasi?	a. Natural a. Permanian beradas	b. Natural c. Permanian beradas
16.	Apakah jenis makanan yang diberi kepada ternakan SEBELUM dan SELEPAS menerimaguna inovasi?	a. Rumput b. Dedak c. Silaj d. Bahan sisa pertanian (jerami padi/ jagung, pelepah sawit/ hampas tebu dan sebagainya) e. Sisa makanan di rumah (sayur, buah, roti dan sebagainya)	a. Rumput b. Dedak c. Silaj d. Bahan sisa pertanian (jerami padi/ jagung, pelepah sawit/ hampas tebu dan sebagainya) e. Sisa makanan di rumah (sayur, buah, roti dan sebagainya)
17.	Adakah anda memberi nutrisi tambahan kepada ternakan?	a. Ya b. Tidak	a. Ya b. Tidak
18.	Adakah anda memberi vaksin kepada ternakan?	a. Ya b. Tidak	a. Ya b. Tidak
19.	Adakah mengamalkan pengurusan biosekuriti di ladang? (Langkah bagi mencegah penyakit berjangkit dan mengawal penyakit daripada merebak)	a. Ya b. Tidak	a. Ya b. Tidak

20.	Jumlah jam bekerja di ladang dalam **sehari**	jam	jam
21.	Purata bilangan lembu yang diternak	ekor	ekor
22.	Purata bilangan **lembu yang dijual dalam setahun**	ekor	ekor
23.	Purata **harga seekor lembu** yang dijual	RM	RM
24.	Purata kos keseluruhan operasi ladang seperti gaji pekerja, elektrik, air, penyelenggaraan, makanan dan vaksin dalam **SEBULAN**	RM	RM
25.	Purata pendapatan bagi aktiviti ternakan dalam **SETAHUN**	RM	RM

		TAHUN 2019
26.	Anggaran jumlah ASET SEMASA (tunai di tangan atau simpanan di bank, inventori seperti baja yang boleh dijual dengan mudah untuk ditukar kepada tunai)	**RM**
27.	Anggaran jumlah ASET BUKAN SEMASA (tanah, peralatan ladang, bangunan, alat penimbang)	**RM**
28.	Anggaran jumlah LIABILITI JANGKA PANJANG (pinjaman jangka panjang yang bayarannya dibuat MELEBIHI SATU TAHUN seperti pembelian tanah, pembelian kenderaan untuk tujuan kegunaan perniagaan)	**RM**
29.	Anggaran jumlah LIABILITI SEMASA (gaji pekerja, makanan lembu, caj letrik, caj air, ansuran pinjaman yang dibayar secara bulanan DALAM TEMPOH SETAHUN sahaja)	**RM**

30. Berikan pandangan sebagai penternak berkenaan situasi sektor penternakan lembu pedaging di Malaysia

BAHAGIAN E: LATAR BELAKANG RESPONDEN Sila nyatakan DAN bulatkan jawapan anda pada ruang yang disediakan		
1.	Umur	_____ tahun
2.	Jantina	a. Lelaki b. Perempuan
3.	Bangsa	a. Melayu b. Cina c. India d. Lain-lain Nyatakan: _____
.4.	Tahap Pendidikan	a. Tidak bersekolah b. Sekolah rendah c. Sekolah menengah d. MCE / SPM e. Diploma/ STPM/ STAM f. Ijazah Sarjana Muda g. Master h. PhD
5.	Pengalaman dalam penternakan lembu	_____ tahun
6.	Pekerjaan utama	a. Penternak b. Kerajaan c. Swasta d. Lain-lain, Nyatakan: _____
7.	Mempunyai pekerjaan sambilan	a. Ya b. Tidak
8.	Berapakah jarak antara ladang anda dengan Jabatan Perkhidmatan Veterinar (JPV)?	_____ km
9.	Lokasi perniagaan	
10.	Saiz ladang	_____ ekar

TERIMA KASIH

APPENDIX 1B

JABATAN PERKHIDMATAN VETERINAR
Department Of Veterinary Services
Kementerian Pertanian dan Industri Asas Tani
Wisma Tani, Blok Podium Lot 4G1 & 4G2
No. 28 Persiaran Perdana, Presint 4
62630 PUTRAJAYA
MALAYSIA

Tel : 603-8870 2000
Faks : 603-8888 6021
E-mel : pro@dvs.gov.my
Laman Web : www.dvs.gov.my

Ruj. Kami : JPV. BPI.600-1/7/1
Tarikh : 13 September 2019

FARAH ADILAH BINTI ABDULLAH
Department of Economics and Agribusiness,
School of Economics, Finance and Banking,
Universiti Utara Malaysia
06010 Sintok, Kedah Darul Aman

Puan,

KELULUSAN UNTUK MENJALANKAN PROJEK PENYELIDIKAN *AN IMPACT EVALUATION OF EXTENSION PROGRAM ON PERFORMANCE OF RUMINANT FARMERS IN PENINSULAR MALAYSIA*

Dengan hormatnya saya merujuk kepada perkara tersebut di atas.

2. Sukacita dimaklumkan bahawa Jawatankuasa Penilaian Projek Penyelidikan(JPPP), Jabatan Perkhidmatan Veterinar **meluluskan** permohonan puan untuk menjalankan projek penyelidikan yang memerlukan data penternak ruminant dengan kerjasama DVS Negeri Kedah, DVS Negeri Kelantan, DVS Negeri Sembilan dan DVS Negeri Johor. Dicadangkan juga puan untuk memasukkan penternak dari DVS Negeri Pahang memandangkan Pahang mempunya jumlah ternakan ruminan yang banyak.

3. Puan diminta untuk menghantar Laporan Kemajuan secara berkala dan Laporan Akhir kajian kepada urusetia JPPP sebagai makluman kajian-kajian yang dijalankan berkaitan dengan Jabatan Perkhidmatan Veterinar.

4. Dengan ini, Jabatan Perkhidmatan Veterinar mengucapkan selamat maju jaya dalam menjalankan projek penyelidikan dan semoga hasil projek penyelidikan tersebut memberi manfaat kepada industri penternakan negara.

Sekian. Terima kasih.

'BERKHIDMAT UNTUK NEGARA'

Saya yang menjalankan amanah,

(DR CHANDRAWATHANI A/P PANCHADCHARAM)
Pengarah
Bahagian Penyelidikan & Inovasi
b.p. Ketua Pengarah Perkhidmatan Veterinar Malaysia

s.k
Pengarah DVS Negeri Kedah
Pengarah DVS Negeri Kelantan
Pengarah DVS Negeri Sembilan
Pengarah DVS Negeri Johor
} Tuan/puan dimohon untuk memberikan kerjasama dalam kajian ini

Shuhada/JK Penilaian Projek Penyelidikan/Data(E)

APPENDIX 2A

Reliability test

```
GET
  FILE='C:\Users\ACER\Dropbox\Data analisis\Data pre test.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
RELIABILITY
  /VARIABLES=Penerimagunaan_inovasi_1 Penerimagunaan_inovasi_2
Penerimagunaan_inovasi_3 Penerimagunaan_inovasi_4
Penerimagunaan_inovasi_5 Penerimagunaan_inovasi_6
Penerimagunaan_inovasi_7 Penerimagunaan_inovasi_8
Penerimagunaan_inovasi_9
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE CORR
  /SUMMARY=TOTAL.
```

Reliability

```
[DataSet1] C:\Users\ACER\Dropbox\Data analisis\Data pre test.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	28	100.0
	Excluded[a]	0	.0
	Total	28	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.897	.902	9

Item Statistics

	Mean	Std. Deviation	N
B1	3.75	.799	28
B2	3.82	.863	28
B3	4.07	.858	28
B4	3.68	1.020	28
B5	3.68	.983	28
B6	2.86	1.177	28
B7	3.36	.989	28
B8	3.86	.803	28
B9	3.79	.787	28

Inter-Item Correlation Matrix

	B1	B2	B3	B4	B5	B6	B7	B8
B1	1.000	.846	.513	.670	.271	.315	.492	.404
B2	.846	1.000	.568	.690	.366	.375	.511	.603
B3	.513	.568	1.000	.493	.424	.157	.449	.660
B4	.670	.690	.493	1.000	.447	.546	.522	.439
B5	.271	.366	.424	.447	1.000	.599	.579	.643
B6	.315	.375	.157	.546	.599	1.000	.554	.408
B7	.492	.511	.449	.522	.579	.554	1.000	.533
B8	.404	.603	.660	.439	.643	.408	.533	1.000
B9	.324	.432	.463	.741	.578	.525	.435	.594

Inter-Item Correlation Matrix

	B9
B1	.324
B2	.432
B3	.463
B4	.741
B5	.578
B6	.525
B7	.435
B8	.594
B9	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
B1	29.11	31.951	.629	.776	.888
B2	29.04	30.628	.723	.818	.881
B3	28.79	31.804	.593	.581	.891
B4	29.18	28.893	.760	.813	.877
B5	29.18	30.226	.655	.599	.886
B6	30.00	29.481	.579	.559	.896
B7	29.50	29.889	.685	.520	.884
B8	29.00	31.259	.709	.741	.883
B9	29.07	31.550	.691	.740	.884

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
32.86	38.275	6.187	9


```
RELIABILITY
  /VARIABLES=Akses_maklumat_1 Akses_maklumat_2 Akses_maklumat_3
Akses_maklumat_4 Akses_maklumat_5 Akses_maklumat_6 Akses_maklumat_7
Akses_maklumat_8
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE CORR
  /SUMMARY=TOTAL.
```

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	28	100.0
	Excluded[a]	0	.0
	Total	28	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.857	.851	8

Item Statistics

	Mean	Std. Deviation	N
G1	3.46	.793	28
G2	3.29	.763	28
G3	3.89	.567	28
G4	4.04	.793	28
G5	3.96	.838	28
G6	3.71	1.013	28
G7	3.86	1.008	28
G8	4.00	.903	28

Inter-Item Correlation Matrix

	G1	G2	G3	G4	G5	G6	G7	G8
G1	1.000	.507	.609	.208	.416	.448	.364	.362
G2	.507	1.000	.245	.350	.017	.157	.007	.000
G3	.609	.245	1.000	.174	.381	.332	.296	.362
G4	.208	.350	.174	1.000	.560	.290	.377	.414
G5	.416	.017	.381	.560	1.000	.729	.871	.881
G6	.448	.157	.332	.290	.729	1.000	.720	.688
G7	.364	.007	.296	.377	.871	.720	1.000	.896
G8	.362	.000	.362	.414	.881	.688	.896	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
G1	26.75	18.417	.558	.604	.844
G2	26.93	20.735	.219	.524	.878
G3	26.32	20.152	.465	.414	.854
G4	26.18	18.967	.470	.571	.853
G5	26.25	16.417	.843	.893	.810
G6	26.50	16.037	.712	.617	.825
G7	26.36	15.720	.764	.849	.818
G8	26.21	16.323	.782	.849	.816

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
30.21	22.841	4.779	8

APPENDIX 2B

Normality test

Descriptives

			Statistic	Std. Error
mean inovasi	Mean		3.0011	.04603
	95% Confidence Interval for Mean	Lower Bound	2.9104	
		Upper Bound	3.0918	
	5% Trimmed Mean		3.0345	
	Median		3.0000	
	Variance		.494	
	Std. Deviation		.70262	
	Minimum		1.00	
	Maximum		4.00	
	Range		3.00	
	Interquartile Range		.63	
	Skewness		-.778	.159
	Kurtosis		.192	.318

Descriptives

			Statistic	Std. Error
umur	Mean		48.40	.894
	95% Confidence Interval for Mean	Lower Bound	46.64	
		Upper Bound	50.16	
	5% Trimmed Mean		48.35	
	Median		50.00	
	Variance		186.189	
	Std. Deviation		13.645	
	Minimum		19	
	Maximum		80	
	Range		61	
	Interquartile Range		22	
	Skewness		-.097	.159
	Kurtosis		-.755	.318

Descriptives

			Statistic	Std. Error
pengalaman	Mean		13.17	.745
	95% Confidence Interval for Mean	Lower Bound	11.70	
		Upper Bound	14.64	
	5% Trimmed Mean		12.09	
	Median		10.00	
	Variance		129.384	
	Std. Deviation		11.375	
	Minimum		2	
	Maximum		60	
	Range		58	
	Interquartile Range		15	
	Skewness		1.435	.159
	Kurtosis		1.618	.318

Descriptives

			Statistic	Std. Error
mean access to info	Mean		3.11	.038
	95% Confidence Interval for Mean	Lower Bound	3.04	
		Upper Bound	3.19	
	5% Trimmed Mean		3.12	
	Median		3.00	
	Variance		.345	
	Std. Deviation		.587	
	Minimum		1	
	Maximum		7	
	Range		5	
	Interquartile Range		1	
	Skewness		.362	.159
	Kurtosis		4.380	.318

Descriptives

			Statistic	Std. Error
mean_bil.lembu_sebelum	Mean		16.5143	3.59560
	95% Confidence Interval for Mean	Lower Bound	9.2071	
		Upper Bound	23.8214	
	5% Trimmed Mean		14.3810	
	Median		5.0000	
	Variance		452.492	
	Std. Deviation		21.27187	
	Minimum		1.00	
	Maximum		85.00	
	Range		84.00	
	Interquartile Range		18.00	
	Skewness		1.610	.398
	Kurtosis		1.840	.778

APPENDIX 2C

Validity test

```
FACTOR
  /VARIABLES A1 A2 A3 A4 A5 A6 A7 A8
  /MISSING PAIRWISE
  /ANALYSIS A1 A2 A3 A4 A5 A6 A7 A8
  /PRINT INITIAL KMO ROTATION
  /PLOT EIGEN
  /CRITERIA FACTORS(2) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX
  /METHOD=CORRELATION.
```

Factor Analysis

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.913
Bartlett's Test of Sphericity	Approx. Chi-Square	1780.002
	df	28
	Sig.	.000

Communalities

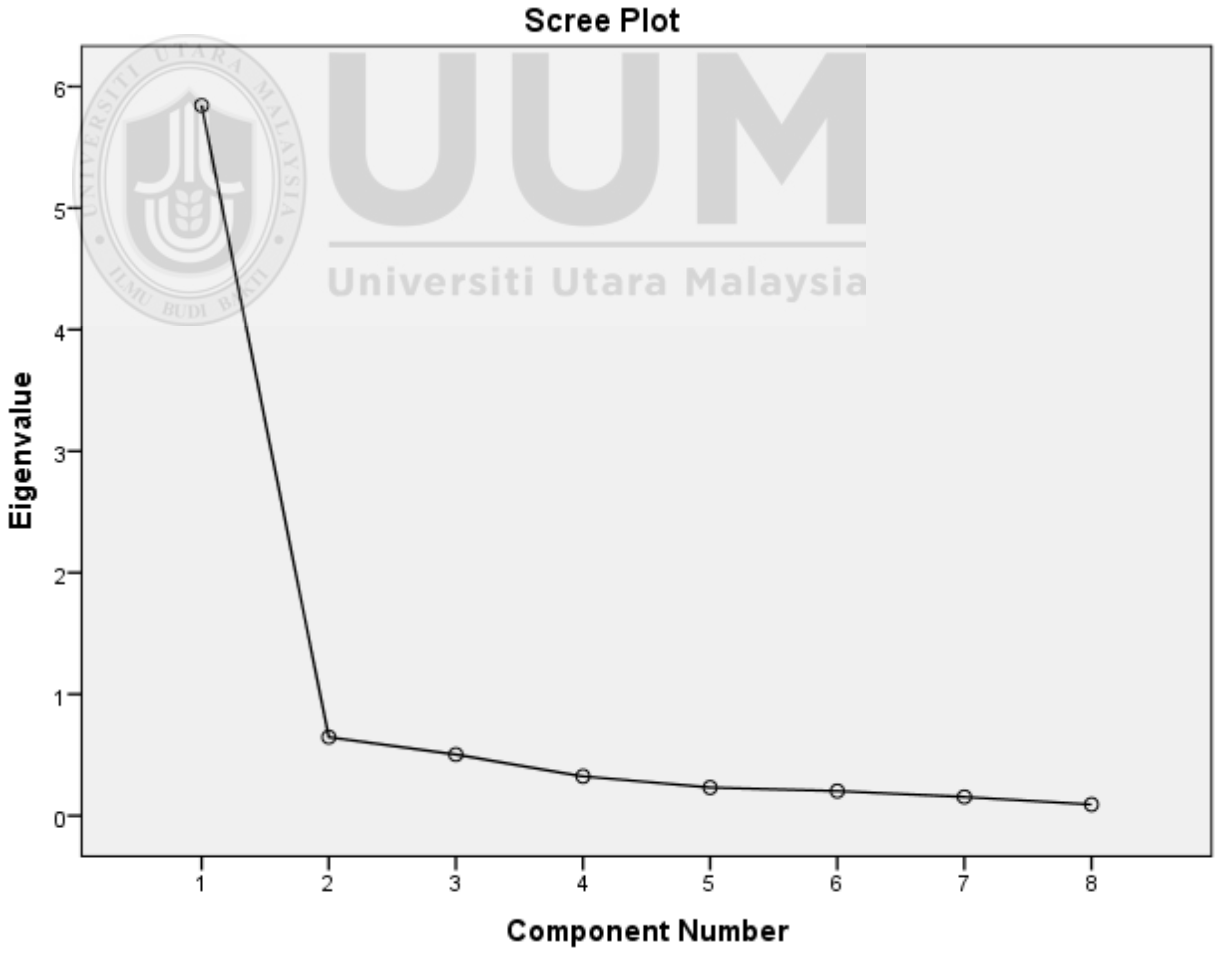
	Initial
inovasi 1	1.000
inovasi 2	1.000
inovasi 3	1.000
inovasi 4	1.000
inovasi 5	1.000
inovasi 6	1.000
inovasi 7	1.000
inovasi 8	1.000

Extraction Method:
Principal Component
Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.845	73.060	73.060	4.503	56.288	56.288
2	.646	8.081	81.142	1.988	24.853	81.142
3	.503	6.290	87.431			
4	.324	4.047	91.479			
5	.232	2.898	94.377			
6	.203	2.538	96.915			
7	.154	1.927	98.842			
8	.093	1.158	100.000			

Extraction Method: Principal Component Analysis.



Component Matrix[a]

a. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
inovasi 1	.915	.206
inovasi 2	.892	.260
inovasi 3	.733	.367
inovasi 4	.830	.310
inovasi 5	.785	.457
inovasi 6	.247	.936
inovasi 7	.698	.529
inovasi 8	.694	.532

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.861	.508
2	-.508	.861

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

APPENDIX 2D

Model Fitting Information

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	399.619			
Final	249.609	150.010	10	.000

Link function: Logit.

APPENDIX 2E

Goodness-of-Fit

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	353.507	382	.849
Deviance	249.609	382	1.000

Link function: Logit.

APPENDIX 2F

Pseudo R-square

Pseudo R-Square

Cox and Snell	.533
Nagelkerke	.614
McFadden	.375

Link function: Logit.

APPENDIX 2G

Test of Parallel Lines

Test of Parallel Lines[a]

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	249.609			
General	236.537	13.072	10	.220

The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

a. Link function: Logit.

APPENDIX 2H

Multicollinearity

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	1.135	.289		3.923	.000	.564	1.706		
	cat access to info	.727	.064	.618	11.293	.000	.600	.854	.851	1.174
	mean_bil.lembu_sebelum	.003	.003	.062	1.190	.235	-.002	.008	.930	1.076
	edu_new	-.060	.063	-.059	-.955	.341	-.184	.064	.664	1.507
	umur	-.001	.004	-.010	-.152	.879	-.008	.007	.544	1.840
	pengalaman	-.005	.004	-.075	-1.242	.216	-.012	.003	.696	1.437
	gov extension1	.019	.101	.011	.189	.850	-.181	.219	.758	1.320
	F2F	-.383	.165	-.148	-2.318	.022	-.708	-.057	.627	1.595

a. Dependent Variable: cat_inovasi

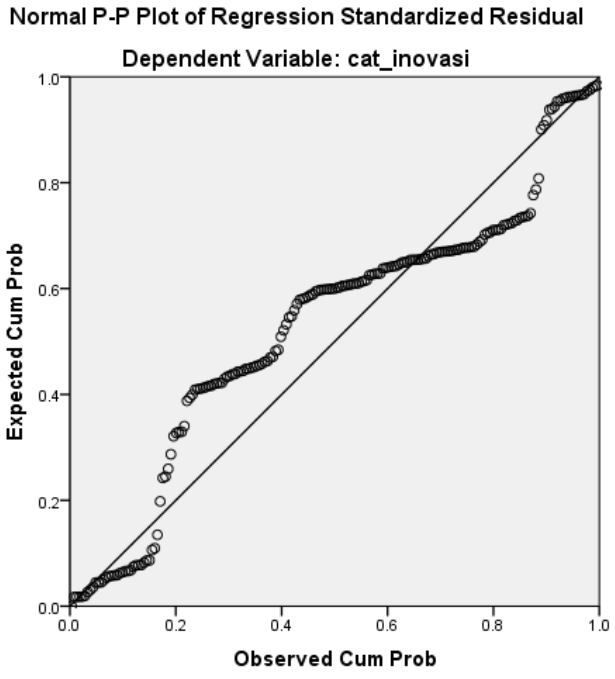
APPENDIX 2I

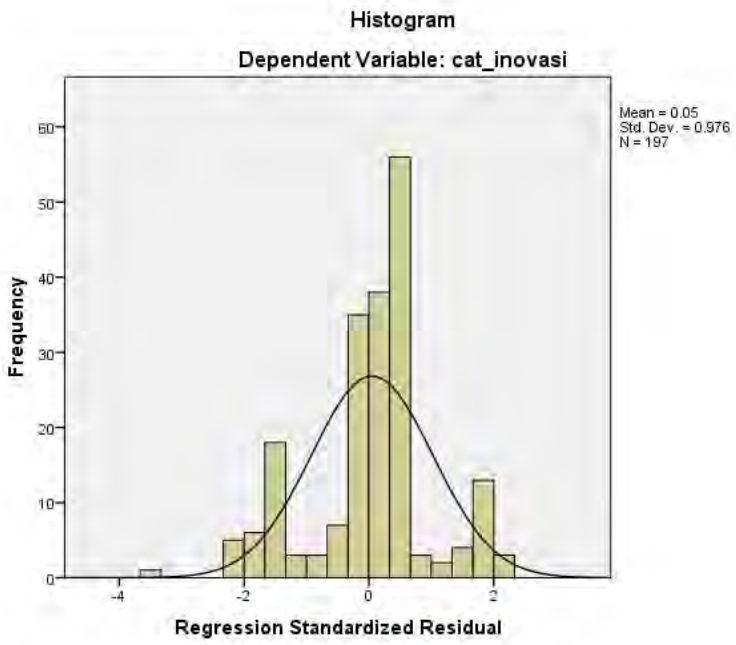
Multivariate Normality

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.7416	3.2274	2.3044	.54110	197
Std. Predicted Value	-3.021	1.718	-.041	1.031	197
Standard Error of Predicted Value	.053	.287	.098	.034	197
Adjusted Predicted Value	.7058	3.3297	2.3037	.54153	197
Residual	-1.77764	1.10075	.02552	.50288	197
Std. Residual	-3.451	2.137	.050	.976	197
Stud. Residual	-3.471	2.193	.050	.994	197
Deleted Residual	-1.79868	1.15888	.02625	.52157	197
Stud. Deleted Residual	-3.578	2.215	.049	1.001	197
Mahal. Distance	1.076	59.850	6.899	6.438	197
Cook's Distance	.000	.038	.005	.007	197
Centered Leverage Value	.005	.305	.035	.033	197

a. Dependent Variable: cat_inovasi





APPENDIX 2J

Logistic Regression

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[cat_inovasi = 1.00]	-2.396	1.591	2.268	1	.132	-5.515	.722
	[cat_inovasi = 2.00]	.545	1.593	.117	1	.732	-2.576	3.667
Location	E1_umur	-.007	.017	.162	1	.688	-.041	.027
	E5_pengalaman	-.022	.018	1.509	1	.219	-.056	.013
	mean_bil.lembu_sebelum	.030	.018	2.935	1	.087	-.004	.064
	[edu_new=1]	1.257	1.016	1.531	1	.216	-.734	3.247
	[edu_new=2]	.694	.880	.622	1	.430	-1.031	2.419
	[edu_new=3]	.840	.894	.883	1	.347	-.912	2.592
	[edu_new=4]	0[a]	.	.	0	.	.	.
	[D9a_JPV=1]	-.325	.525	.383	1	.536	-1.354	.704
	[D9a_JPV=2]	0[a]	.	.	0	.	.	.
	[D10a_F2F=1]	2.069	.808	6.561	1	.010	.486	3.651
	[D10a_F2F=2]	0[a]	.	.	0	.	.	.
	[cat_access_info=1]	-6.504	1.154	31.772	1	.000	-8.765	-4.242
	[cat_access_info=2]	-2.983	.400	55.689	1	.000	-3.766	-2.199
	[cat_access_info=3]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

APPENDIX 2K

Calculations for the Total Cost

DataSet1] C:\Users\ACER\Dropbox\Data analisis\Data April_6.sav

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
mean_kos.sblm	233	.00	9500.00	640.6009	1011.92739
mean_bil.lembu.slps	233	2.00	250.00	23.6910	33.93031
mean_bil.lembu_sebelum	233	1.00	120.00	11.3348	14.67256
mean_kos.slps	233	.00	10400.00	1336.2446	1870.77425
mean_farmsize	233	.00	40.00	3.4696	5.03922
Valid N (listwise)	233				

Total cost of one unit beef cattle (before):

RM 640.6 ÷ 11 = RM 58.2 / month

Total cost of one unit beef cattle (after):

RM 1336.2 ÷ 23 = RM 58.1 / month

Total cost for one acre of land in rearing beef cattle:

RM 1336.2 ÷ 3 = RM 445.4 / month

APPENDIX 2L

Paired-samples T-test

```
[DataSet1] C:\Users\ACER\Dropbox\Data analisis\Data April_3.sav
```

Total cost and total revenue

Paired-samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	kos sebelum	640.60	233	1011.927	66.294
	kos selepas	1336.24	233	1870.774	122.558
Pair 2	bil.lembu sebelum	11.33	233	14.673	.961
	bil.lembu selepas	23.69	233	33.930	2.223
Pair 3	bil.lembu.harga_before	41952.3605	233	57763.43108	3784.20819
	bil.lembu.harga_after	104881.1159	233	151383.79601	9917.48222

Paired-samples Correlations

		N	Correlation	Sig.
Pair 1	kos sebelum & kos selepas	233	.712	.000
Pair 2	bil.lembu sebelum & bil.lembu selepas	233	.569	.000
Pair 3	bil.lembu.harga_before & bil.lembu.harga_after	233	.497	.000

Paired-samples Test

		Paired Differences			
					95% Confidence Interval of the Difference
		Mean	Std. Deviation	Std. Error Mean	Lower
Pair 1	kos sebelum - kos selepas	-695.644	1352.296	88.592	-870.191
Pair 2	bil.lembu sebelum - bil.lembu selepas	-12.356	28.280	1.853	-16.006
Pair 3	bil.lembu.harga_before - bil.lembu.harga_after	-62928.75536	132492.05339	8679.84301	-80030.14607

Paired-samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Upper	t	df	Sig. (2-tailed)
Pair 1	kos sebelum - kos selepas	-521.096	-7.852	232	.000
Pair 2	bil.lembu sebelum - bil.lembu selepas	-8.706	-6.669	232	.000
Pair 3	bil.lembu.harga_before - bil.lembu.harga_after	-45827.36466	-7.250	232	.000

Northern region

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	profit_sblm	48040.0000	35	74738.36010	12633.08861
	profit_slps	148727.4286	35	192481.16162	32535.25454

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	profit_sblm & profit_slps	35	.871	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	profit_sblm - profit_slps	-100687.42857	132552.91668	22405.53230	-146220.94857	-55153.90857	-4.494	34	.000

Central region

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	profit_sblm	92690.9091	11	47016.45360	14175.99414
	profit_slps	156827.2727	11	121198.38358	36542.68759

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	profit_sblm & profit_slps	11	.819	.002

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	profit_sblm - profit_slps	-64136.36364	87001.03761	26231.79983	-122584.45599	-5688.27128	-2.445	10	.035

East-coast region

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	profit_sblm	27544.4586	157	49127.35029	3920.78939
	profit_slps	41247.1338	157	67034.08547	5349.90244

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	profit_sblm & profit_slps	157	.596	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	profit_sblm - profit_slps	-13702.67516	54621.98412	4359.30891	-22313.56360	-5091.78672	-3.143	156	.002

Southern region

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	profit_sblm	31943.3333	30	35548.05085	6490.15644
	profit_slps	243160.0000	30	197110.15055	35987.22526

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	profit_sblm & profit_slps	30	-.002	.990

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	profit_sblm - profit_slps	-211216.66667	200375.49421	36583.39272	-286038.10586	-136395.22747	-5.774	29	.000

APPENDIX 3

Pictures during the Data Collection

Integration system in oil palm plantation at Parit Yaani, Batu Pahat, Johor.

Beef cattle farmer does not implement biosecurity management at their farm in Pekan Atap, Gurun, Kedah.

Face-to-face interview between the researcher and beef cattle farmer at Kampung Parit Tengah, Rengit, Batu Pahat, Johor.

The processing centre of agricultural waste. Corn straws are used as the option for cattle feed. This centre is handled by a farmer at Rengit, Batu Pahat, Johor.

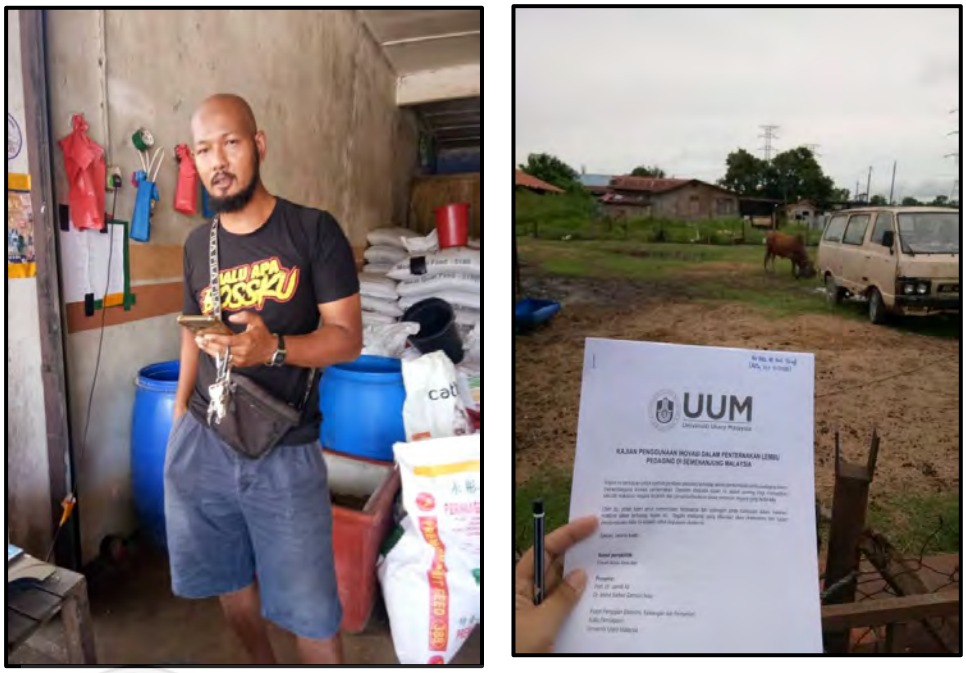
Systematic and organized storage of farm equipment at a farm in Banting, Selangor.

Integration and feedlot system practised by a cattle farmer at Banting, Selangor.

Range feeding technique in Jitra, Kedah. The ruminants are grazing by the roadside.

Napier crops as a source of cattle feed at a farm in Banting, Selangor.

Pellet is also given at certain times instead of the grazing activity at the palm oil plantation.



Interviewing one of the beef cattle farmer at his farm in Tanah Merah, Kelantan.