Adoption of Internet of Things along Halal Food-Based SMEs Supply Chain in Malaysia

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ABSTRACT

In the food industry particularly, the supply chain involves multilevel players from suppliers to end consumers. In uplifting food supply chain safety value, the halal concept has been introduced to the food industry in addition to other existing safety certificates such as Good Agricultural Practice (GAP), Hazard Analysis and Critical Control Points (HACCP), and Good Manufacturing Practice (GMP). The halal supply chain ensures high quality production of halal food and is a new realm with immense market potential driving the global economy. The efficiency along the food supply chain integrated with the advent of technology has boosted the applicability of products traceability system. The use of Internet of Things (IoT) in the traceability system has facilitated supply chain players in managing their products information along the chain. As one of the significant halal industry players, SMEs are slow in adopting IoT. With IoT, halal food-based SMEs supply chain will no doubt provide a trusted platform but the number of halal scandals and issues in the market continues

to increase. Therefore, the objective of this study was to investigate the adoption of IoT along halal food-based SMEs supply chain in Malaysia. Data were gathered among selected 30 halal food-based SMEs based on self-administered questionnaires. The results showed that most of the halal food-based SMEs displayed a low level of IoT adoption in managing their halal products production processes. Therefore, radical changes are necessary for implementing IoT among Malaysian halal food-based SMEs.

Keywords: *Food-based SMEs, Halal, Halal Supply Chain, IoT*

INTRODUCTION

Effective communication and systematic information system are essential to enhance the efficiency, productivity, and return on investment (ROI) of firms. Information and communication technology (ICT) is paramount to the industrial communication and information system but the functionality of Industrial Revolution 4.0 (IR 4.0) will be futile without the internet. The introduction of steam power and mechanization in productions during the 18th century marks the beginning of the revolution in the development of industrial technology, also known as Industry 1.0. The constant advancement of technology from electricity and semi-automation computers control program until recently has seen the arrival of the latest phase of IR 4.0 which introduces the concept of smart devices and factories. IR 4.0 is expected to enhance industrial efficiency, productivity, ROI, technology convergence, and megatrends. Without the internet, any industry will lag behind IR 4.0.

In the global business environments, small and medium enterprises (SMEs) are increasingly using information and communication technology (ICT) to gain competitive advantage and to support business activities (Kamarulzaman and Eglese, 2013; Ghobakhloo et al., 2011). Early studies by Feher and Towell (1997), Hamill (1997), and Paul (1996) indicated that businesses have started using the internet for many years way back. In particular, Paul (1996) described that information superhighway is very crucial in providing the unlimited potential to a firm to compete in the world markets. According to Hamill (1997), the association between the internet and ICT brings an explosion in business marketing activities. On the other hand, Feher and Towell (1997) highlighted the importance of the

internet for business growth and the significant value of a business to a firm. According to Wilkesmann and Wilkesmann (2018), IR 4.0 is a new era of ICT where real product information is linked to the web-based application and integrated into the production process. The key to IR 4.0 integrated production process among industry practitioners is Internet of Things (IoT). IoT is a part of ICT characterized by smart things and a fusion of technologies and interaction across physical, digital, and biological domains (Nainy, 2017) that enables IR 4.0. IoT helps to cut the cost of implementation (Li et al., 2017), improve performance of supply chain (Zhang et al., 2017), increase in data quantity and speed (Parry et al., 2016), and accelerate SCM decision-making process (Rezaei et al., 2017).

There are studies on SMEs grappling with technological constraints in adopting IoT due to the lack of education and technical skills, which are critical means in gaining competitive advantage in this global marketplace (Tan et al., 2009). Simmons et al. (2007) noted the ambiguity of internet adoption among SMEs and most SMEs still underestimated the potential value of the internet by restricting its utilization for basic management tasks (Ramdani et al., 2013). Most SMEs are engaged in low value-added activities that centered around 'traditional' rather than 'modern' productions and business transactions (Kamarulzaman and Mohamed, 2013).

The emergence of halal food industry is important in delivering halal value food to consumers. Hence, IoT is believed to be an effective business tool to boost halal supply chain performance and increase the quality of halal products. Given the significant contribution of halal food-based SMEs in Malaysia, incorporating advanced technology in the food and beverage (F&B) industry is indispensable that will not only ensure the quality of products but also fulfilling the potential of the industry (Abdul et al., 2017). However, there are findings indicated that halal food-based SMEs are still reluctant in embracing ICT in their production process as well as in the halal supply chain system (Abdul et al., 2017; Ramdani et al., 2013; Tan et al., 2010). Thus, this study was carried out to investigate the adoption of IoT along halal food-based SMEs supply chain in Malaysia.

LITERATURE REVIEW

Halal and haram are the rules and spines in Muslims' daily lives in accordance with Shariah. Halal is the things or actions permitted by the Shariah without punishment imposed on the doer. The term halal covers a broad scope such as food and beverage consumptions, human relations, business, trade, finance, and every aspect of behavior (Samori et al., 2014). Halal can be summarized as a permissible, lawful, sanctioned, and permitted action, which is based on Islamic values (Badruldin et al., 2012). Besides, halal also serves as a standard dietary guideline for Muslims, as provided in al-Quran (Marzuki et al., 2012; Rezai et al., 2012). Therefore, halal approach to the supply chain is necessary (Tieman, 2011; Wilson & Liu, 2011). In the food industry, the halal supply chain is an important dynamic link in delivering halal value of food products or services to end-consumers.

Besides halal certificate, there are other existing food safety certificates such as Good Agricultural Practice (GAP), Hazard Analysis and Critical Control Points (HACCP), Good Manufacturing Practice (GMP), and even eco-labeling. HACCP and GMP, for instance, describe the operational and environmental conditions necessary in safe food production. The regulations ensure the safe handling of ingredients, products, and packaging materials for processing in a suitable environment (Rezai et al., 2012). Meanwhile, GAP verifies fresh agricultural produce that accords to the Food and Agriculture Organization (FAO) (2016), whereas other food safety certificates such as halal certificates offer halal security and halal value of food sources especially for Muslims consumers that are in accordance with Shariah.

Internet of Things (IoT) is a new era of ICT for the industry. It allows multi-layer supply chain players to communicate effectively and efficiently for better and outstanding decision-making. It is also one of the effective ways of solving information management problems among industry practitioners (Yan et al., 2016). Product information management is a critical part of the supply chain since it involves more than one player along the chain. Thus, the presence of IoT helps to boost halal supply chain performance in many ways. IoT is referred to as a dynamic global network infrastructure where objects are connected, monitored, and optimized through either wired, wireless, or hybrid systems (Zhang et al., 2017). IoT is an extension of the internet by integrating mobile networks, internet, social

networks, and intelligent things to provide better services or applications to users (Li et al., 2016).

According to Del Giudice (2016), IoT connects people, goods, and operations through a global network and increases global competitiveness. IoT also provides network connectivity in which it extends to objects, sensors, and everyday devices to generate, exchange, and consume data with minimum human intervention (Rose et al., 2015). Thus, IoT is all about smart devices connected by the internet where information is stored in the cloud available for access by a human to expedite decision-making, increase profit, and reduce waste and operation period.

Adoption of technology such as ICT and IoT is crucial for the company in creating competitive advantages and enhance the handling of products along the business supply chain (Kamarulzaman and Eglese, 2013; Tan et al., 2012). Furthermore, these technologies also help the company to conduct buying and selling goods online (Ramdani and William, 2013) and reduce the costs of information processing and communication within internal management as well as in between companies along the supply chain (Milinillo and Japutra, 2017). Technologies such as ICT and IoT reduce operating costs, lower sales, and purchasing costs while increasing market share as well as enhancing relationships with partners and customers. Despite the various advantages of adopting the technology among supply chain players, an empirical study measuring the level of adoption is required to investigate the real situation.

There are many ways of measuring the adoption level across different industries. For instance, Nainy (2017) measured the adoption level among SMEs towards IR 4.0 by studying the factors such as low cost, easy access, and peer pressure while Karipidis et al. (2009) deliberated on benefits and barriers in measuring adoption level among food SMEs towards quality assurance systems. Molinillo and Japutra (2017) in their study discussed the organizational adoption of digital information and technology by using three main theories namely Theory Diffusion of Innovation (DOI), Theory of Reasoned Action (TRA), and Technology Acceptance Model (TAM).

In DOI, Rogers (1995) highlighted the adoption of innovation is influenced by a group of characteristics such as complexity, compatibility,

trialability, and observability. Molinillo and Japutra (2017) identified in their study that many of the previous studies used DOI to explain the adoption of information technology among SMEs. However, the knowledge aspect, above all the characteristics described in DOI is necessary for the adoption of innovation or new technology (Ibrahim and Mokhtarudin, 2010).

TRA is the first model of adoption theory that was originally proposed by Fishbein and Ajzen in 1975 (Dang and Pham, 2018). Wallace and Sheetz (2014) elucidated that TRA model rests on an underlying assumption where the intention is the best predictor of an individual's behavior, which is highly determined by the attitude towards the performance of and subjective norm associated with a behavior. However, TRA components may be insufficient individual behavior (Ajzen, 1991).

On the other hand, in TAM, beliefs are determinants of individual intentions to adopt a particular technology (Davis, 1989). Two variables, namely perceived ease of use (PEOU) and perceived usefulness (PU) are included in TAM. Perceived ease of use (PEOU) explains the degree to which an individual believes that using a particular system would be free of physical and mental effort while perceived usefulness (PU) explains the degree to which an individual believes that using a particular system would enhance his or her job performance (Dang and Pham, 2018).

METHOD

The conceptual framework of this study was developed based on previous literature from Davis (1989), Kesharwani and Bisht (2012) and Dang and Pham (2018), where the variables of perceived ease of use (PEOU) and perceived usefulness (PU) in TAM provide significant measurement in the study of technology adoption. Studies by Ibrahim and Mokhtarudin (2010), Ahmad Tarmizi et al. (2014), and Molinillo and Japutra (2017) highlighted the knowledge aspect adapted from DOI as a fundamental element in the implementation of innovation or something or new.

There were three main variables identified to investigate the adoption of IoT along halal food-based SMEs supply chain in Malaysia as illustrated in Figure 1. The hypotheses of this study were established such as the following:

H_0: There is no relationship between knowledge level and adoption of IoT along halal food-based SMEs supply chain.
H_1: There is a relationship between knowledge level and adoption of IoT along halal food-based SMEs supply chain.

H_0: There is no relationship between perceived ease of use and adoption of IoT along halal food-based SMEs supply chain.
H_2: There is a relationship between perceived ease of use and adoption of IoT along halal food-based SMEs supply chain.

H_0: There is no relationship between perceived usefulness and adoption of IoT along halal food-based SMEs supply chain.
H_3: There is a relationship between perceived usefulness and adoption of IoT along halal food-based SMEs supply chain.

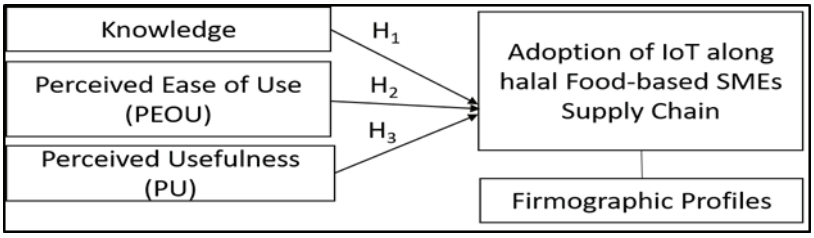

Figure 1: Conceptual Framework of IoT Adoption along Halal Food-based SMEs Supply Chain
Source: Rogers (1995); Ibrahim and Mokhtarudin (2010); Ahamd Tarmizi et al. (2014); Dang and Pham (2018)

To measure the adoption of IoT along halal food-based SMEs supply chain in Malaysia, 30 Malaysian halal food-based SMEs were approached at the halal exhibition, HALFEST 2018 at Kuala Lumpur which was held in September 2018. A quantitative survey approach was employed based on self-administered questionnaires using a structured questionnaire. Since this is a preliminary study, a convenience sampling technique was used due to time limitations. The structured questionnaire consisted of several questions focusing on the adoption and use of IoT in the production of halal food products along halal food-based SMEs supply chain were established. Independent and dependent variables were formed based on a 5-point Likert scale (1-strongly disagree, 2-disagree, 3-neither agree nor disagree, 4-agree,

and 5-strongly agree) and the collected data were analyzed using several statistical analyses namely descriptive analysis, mean score analysis, mean ranking analysis, and Pearson correlation analysis.

Descriptive analysis was carried out to analyse the firmographic profiles while mean score analysis was employed to measure the knowledge score based on scoring table adapted from Appiah et al. (2011) and Vaiappuri et al. (2012). There were 10 statements related to IoT established with three choices of answers based on three (3) scales namely 3-true, 2-not sure, and 1-false. For each correct answer, a score of one (1) was given while an incorrect answer was given a zero (0) score. For those choosing 'not sure' as their answer, the score was also given zero (0) because this indicates a lack of knowledge by halal food-based SMEs on the statement. Based on the score, a cumulative score between 5 to 10 indicates a high knowledge level while a cumulative score between 0 to 4 indicates a low knowledge level of respondents. Mean ranking analysis was also used to measure the respondents' perception namely perceived ease of use (PEOU) and perceived usefulness (PU) of IoT in managing their business operations. Ten statements based on a 5-point Likert scale were established and asked to the respondents. Meanwhile, Pearson correlation analysis was used to analyze the relationship between perceived ease of use (PEOU), perceived usefulness (PU), and knowledge of IoT along the halal food-based SMEs supply chain. The analysis measures the direction and strength of the relationship whether it is negative, positive, or zero by using *r*-value where more than 0.7 indicates a strong relationship while *r*-value that below 0.7 indicates a weak relationship (Rankin & Stokes, 1998; Moore et al., 2013).

RESULTS AND DISCUSSIONS

SMEs Firmographic Profiles

Table 1 shows the result of SMEs profiling. Out of 30 SMEs participated in this study, the majority of the halal food-based SMEs were from Selangor accounted for 23 (76.7%) while the rest five SMEs (16.7%) were from Penang, one SME (3.3%) from Negeri Sembilan, and one SME (3.3%) from Sabah. The majority of the respondents were the manager of the company accounted for 8 (26.7%). Seven (23.3%) of the respondents

were the executive, while six (20 %) respondents were the owner and six (20%) respondents were the marketing team (officer or promoter), and three respondents (10%) were the officers from operation line.

The majority of the halal food-based SMEs (23, 76.7%) hired Muslim workers while the rest of the SMEs (7, 23.4%) hired both Muslim and non-Muslim workers. The presence of Muslim workers was crucial in maintaining halal integrity along the halal food supply chain and a minimum of two Muslim workers are required according to the Malaysian Standard (MS) for halal food handling (MS 1500:2010) as well as for halal certification application in Malaysia. Electronic devices are among the important components in applying IoT. The result revealed that all SMEs in this study used basic electronic devices such as laptops and smartphones in managing their business. SMEs were revealed to have access to the internet to get connected with their business dealings.

Table 1: Halal Food-Based SMEs Firmographic Profiles

	Profiles	Frequency (n)	Percentage (%)
State	**Selangor**	23	76.7
	Penang	5	16.7
	Negeri Sembilan	1	3.3
	Sabah	1	3.3
SMEs Representative	**Manager**	8	26.7
	Executive	7	23.3
	Owner	6	20
	Marketing team	6	20
	Operation officer	3	10
Workers	**Muslims workers**	23	76.7
	Both Muslims and non-Muslims	7	23.4
Use of electronic devices	**Yes**	30	100

n=30

Knowledge Level on IoT

Knowledge is an important and basic element of understanding a new thing. To adopt IoT in the supply chain activities, SMEs must be informed of what IoT is all about. Ten statements were constructed related to IoT and other relevant information based on three (3) scales namely 3-true, 2-not sure, and 1-false. Mean score analysis was used to simplify the data into the scoring system. Based on the scoring table adapted from Appiah et al. (2011) and Vaiappuri et al. (2012), knowledge was categorized into two levels which are low and high.

Table 2 shows the result of the knowledge level on IoT among halal food-based SMEs based on mean score value. In this study, a mean score of 5 to 10 indicates halal food-based SMEs have high level knowledge of IoT while the mean score from 0 to 4 indicates that the halal food-based SMEs have low knowledge of IoT. Out of 30 halal food-based SMEs involved in this preliminary study, 60% (18) of SMEs showed that they have high knowledge of IoT and how it could improve their supply chain activities management while the remaining 40% (12) of halal SMEs indicated otherwise, that is they have little or low knowledge about IoT and how the technology could improve their supply chain management.

Table 2: Knowledge Level among Halal Food-Based SMEs on IoT

Mean score	Frequency (n)	Percentage (%)
High (5-10)	18	60
Low (0-4)	12	40

n=30

According to Brand and Huizingh (2008), the decision process of adopting new technology begins with awareness of the existence and learning about the innovation while Simmons et al. (2007) argued awareness about IoT should be developed to prevent the negative perception of internet adoption among SMEs. Hence, there is a need to address the SMEs that IoT is an effective business tool to stay competitive in the market. Thus, knowledge is believed to play vital roles to create better awareness of IoT to halal food-based SMEs in Malaysia.

MEAN RANKING ANALYSIS OF PERCEIVED EASE OF USE AND PERCEIVED USEFULNESS

Perceived ease of use (PEOU) and perceived usefulness (PU) variables were analyzed based on mean ranking analysis. There were five (5) statements established to measure respondents' perceived ease of use (PEOU) on IoT while another five (5) statements were established to obtain respondents' perceived usefulness of IoT. The result of the statements was arranged based on their mean value from the highest to the lowest as in Table 3.

Table 3: Mean Ranking Analysis of PEOU and PU

	Statements	Mean	SD	Overall Mean
PEOU	PEOU1 - IoT devices facilitate the company in managing product information.	3.90	0.885	3.806
	PEOU2 - IoT devices assist company to track and trace products along the production line.	3.80	0.847	
	PEOU3 - IoT devices increase data visibility of products along halal supply chain.	3.80	0761	
	PEOU4 - IoT devices provide flexible management of products movement and shipment.	3.83	0.747	
	PEOU5 - IoT systems help in halal food supply chain trend analysis.	3.70	0.750	
PU	PU1 - IoT devices provide faster information and ease communication between supply chain players.	3.83	0.747	3.800
	PU2 - IoT systems improve traceability of halal products along supply chain.	3.83	0.791	
	PU3 - IoT devices provide greater insight of information between supply chain players.	3.80	0.761	
	PU4 - IoT devices improve the authentication of ingredients selection for halal production.	3.77	0.817	
	PU5 - IoT increases efficiency among supply chain players in managing halal products.	3.77	0.728	

Based on the statements to measure PEOU, it revealed that the highest mean score was the statement indicating that '*IoT devices facilitate company in managing product information*' with a mean score of 3.90. While based on the statements to determine PU, the results indicated that both the statements of '*IoT devices provide faster information and ease communication between supply chain players*' and '*IoT systems improve traceability of halal products along supply chain*' revealed the highest mean score of 3.83 respectively. The average mean score of PEOU was 3.806 while PU was 3.800, indicating that halal food-based SMEs perceived IoT to benefits them in terms of ease of use and usefulness.

ADOPTION OF IOT OF HALAL FOOD-BASED SMES SUPPLY CHAIN

There were three (3) hypotheses tested using Pearson correlation analysis to investigate the relationship between knowledge, perceived ease of use (PEOU), perceived usefulness (PU) towards the adoption of IoT along halal food-based SMEs supply chain. As shown in Table 3, the *r*-values for knowledge, perceived ease of use (PEOU), and perceived usefulness (PU) towards the adoption of IoT were 0.117, 0.139, and 0.139, respectively. All values showed positive signs, hence the positive relationships between knowledge level, perceived ease of use (PEOU), and perceived usefulness (PU) and the adoption of IoT. However, the *r*-values of all three variables were below 0.7 indicating weak relationships between the variables. The result also showed that perceived ease of use (PEOU) has a significant relationship with the adoption of IoT ($p=0.065$) at a 10% level of significance, hence H_0 was rejected. The other two variables, knowledge level ($p=0.537$) and perceived usefulness (PU) ($p=0.464$) were found not significant, thus failed to reject H_0. It can be concluded that there was a significant relationship between perceived ease of use (PEOU) and adoption of IoT along halal food-based SMEs supply chain while there were no significant relationships between knowledge and perceived usefulness (PU) with the adoption of IoT along halal food-based SMEs supply chain.

Table 4: Relationship between Knowledge, Perceived Ease of Use, Perceived Usefulness and Adoption of IoT along with Halal Food-Based SMEs Supply Chain

	Pearson correlation (*r*)	Sig. (2-Tailed)	Decision
Knowledge	0.117	0.537	Failed to reject H_0
Perceived ease of use (PEOU)	0.139	0.065***	Reject H_0
Perceived usefulness (PU)	0.139	0.464	Failed to reject H_0

Note: ***Correlation is significant at 10% level of significance

Based on the findings, it can be concluded that the adoption of IoT along halal food-based SMEs supply chain is still low. The finding was supported by the earlier study of Tan et al. (2010) that many SMEs in the Asia-Pacific region and Malaysia is one of the countries that have yet to reap the benefits of IoT. The low adoption of IoT along halal food-based SMEs supply chain can be attributed to poor telecommunication infrastructure, limited internet literacy, inability to integrate the internet into business processes, high costs of internet equipment, incomplete government regulations for e-commerce, and poor understanding of the dynamics of the knowledge economy.

CONCLUSION

In Malaysia, halal food-based SMEs play a significant role in providing certified halal food for Muslim and non-Muslim consumers. Even though the halal industry addresses more on religious needs and requirements, an effective business tool integrating IoT in firm management is critical to boost business performance. The emerging global technology requires halal food-based SMEs to jump into the bandwagon to remain competitive in the local and global markets. To achieve this, the halal food-based SMEs must realize the benefits of IoT in managing halal supply chain activities. Technology such as IoT is believed to reduce mental and physical efforts

and help to improve the performance in managing supply chain activities of the firm. Therefore, acquiring information on the level of knowledge among halal food-based SMEs on technology aspects especially on IoT is necessary for authorized bodies to provide an appropriate program in disseminating knowledge for halal food-based SMEs as well as encouraging them to find their initiatives to stay align and keep up with the current business trend.

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