FACTORS AFFECTING IOT ADOPTION IN FOOD SUPPLY CHAIN MANAGEMENT

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ABSTRACT

Increasing trends and interest in Food Supply Chain Management (FSCM) research has been documented over the years. The food supply chain is more complex and challenging to manage as compared other supply chains as it involves critical food conditions including quality, safety, and freshness. As the advancement of technology reshapes society and consumer behavior, the current emerging challenge for FSCM is to meet the increasing demand and the higher expectations of food quality from the customers. Adopting disruptive technology such as IoT may be an attainable way to upgrade and reshape a smart FSCM in the environment of Industry 4.0. The IoT emerges as a data-driven technology that is promising to bring significant improvement to FSCM as a whole system. Nonetheless, the tendency to employ IoT in FSCM varies across organizations due to various reasons. With this knowledge, the purpose of this paper was to investigate and identify factors affecting the adoption of IoT as a disruptive technology in supply chain management. To meet our objectives of this research, we employed a systematic literature review of 45 peer-reviewed journal articles on the topic of IoT in supply chain management. The review findings showed that factors affecting IoT adoption vary in terms of context and approach used. The list of the most important factors included performance perceived benefit, cost, data complexity, compatibility, technical knowledge, hardware & infrastructure, peers and government support, security & privacy concern, and adoption willingness.

Keywords: Food Supply Chain Management (FSCM), disruptive technology, IoT

1. INTRODUCTION

Increasing trends and interest in the management of supply chain in general has been documented over years (Aamer, 2004, 2008b). However, more interest the food supply chain has been documented too. Food supply chain has a peculiarity under the study of supply chain management, which is referred to as Food Supply Chain Management (FSCM). FSCM thoroughly differs from other supply chain managements. The food supply chain is more complex and challenging to manage as compared with other supply chains as it involves critical food conditions

including quality, safety, and freshness (Ray Zhong et al, 2017). From a management perspective, food supply chain deals with the challenge of perishable products and large number of involved actors which make it an area of great interest for researchers and practitioners (Ben-Daya et al, 2017).

Increasing study interest in FSCM goes hand in hand with the increasing role of information technology. As the advancement of technology reshapes supply chain, society, and consumer behavior, the current emerging challenge for supply chain and FSCM is to meet the increasing demands and higher expectations of food quality from customers (Aamer 2019, 2018a, 2017). To address the challenge, the current FSCM inescapably needs to perform better. The most important measure of food supply chain performance, as suggested by Rong et al (2011), happens to be maintaining high food quality, considering that food quality encompasses other food properties including safety and freshness. Several prior studies on the related topic have described how FSCM has an important impact on food quality. For instance, Gang Liu (2018) identified that quality cooperation among the food supply chain actors would result in a positive effect on food quality; L. Manning et al (2006) pinpointed that a food supply chain embedded with quality assurance models would drive the improvement of food quality and safety; and Myo Min Aung and Yoon Seok Cang (2014) recognized that traceability in the food supply chain would assure food quality and safety as well as customer satisfaction. Henceforth, paying attention to FSCM profoundly in any aspect is a necessity for food industry to provide the food quality desired by the customers.

In the environment of Industry 4.0, FSCM must be overseen, not only to merely ensure food quality in the hand of customers, but also to uphold the company's position in the dynamic market under the influence of rapid changing technology. The more a food company is adapted to technology innovation, the more likely it will not lag behind other companies in terms of business competition. Accordingly, the food industry is expected to conduct its supply chain activities in a smarter way than it has ever been before. Adopting disruptive technology such as IoT may be an attainable way to upgrade and reshape a smart FSCM in a company. This is also supported by the findings of Ray Zhong et al (2017) that data-driven decision making including Big Data Analytics, Cloud Computing, and IoT for FSCM leads to improvements that make the food supply chain more sustainable and adaptive.

The Internet of Things (IoT) is currently one of the most trending disruptive technologies applied in various industrial sectors. Global System for Mobile Communications Association (GSMA) defines IoT as "the use of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects". Nonetheless, the definition of IoT extends and evolves depending on the context of where it is used. Mohamed Abdel-Basset et al (2018) defined IoT in context of supply chain management as a set of digitally connected physical objects for sensing and monitoring supply chain interaction, agility, visibility, as well as sharing of information within a firm in order to facilitate plan, control, and coordination for supply chain processes. It is noted that supply chain studies addressing the topic of IoT, both by researchers and practitioners, have been increasing during the last 10 years (Arun Aryal et al, 2018). Findings from Ben-Daya et al (2017) further implied that many research papers dealing with IoT application in the food supply chain appeared recently, confirming it to be a topic of worth to study in industrial management.

The IoT emerges as a data-driven technology that is promising to bring significant improvement on FSCM as a whole. Nonetheless, the tendency to employ IoT in FSCM varies across organizations due to various reasons. Only a few numbers of food companies have managed to successfully implement internet-based technology in their business, while others end up failing which surprisingly contradicts the fact that the technology facilitates the improvement of the food

chain (M. Bourlakis & A. Matopoulos, 2010). Aside from the cases of success and failure in IoT adoption, there are also companies that do not attempt or even still have no intention to do so. According to a McKinsey report in 2017, several organizations are struggling with the difficulty to seize in-depth opportunities with disruptive technologies to redefine supply chain processes and drive supply chain improvement. Therefore, it is reasonable to assume that there are diverse factors that are considered differently by each food company to adopt IoT in its own FSCM.

Upon this knowledge, the purpose of this paper was to investigate factors affecting the adoption of IoT as a disruptive technology in supply chain management. To meet our objectives of this research, we employed a systematic literature review of 45 peer-reviewed journal articles on the topic of IoT in supply chain management.

2. METHODOLOGY

In this paper we followed a systematic literature review (SLR) suggested by Chitu Okoli and Kira Schabram (2010) with four major stages comprising eight essential steps as shown in Figure 1. The eight steps of SLR utilized in this study are briefly described in the following section.

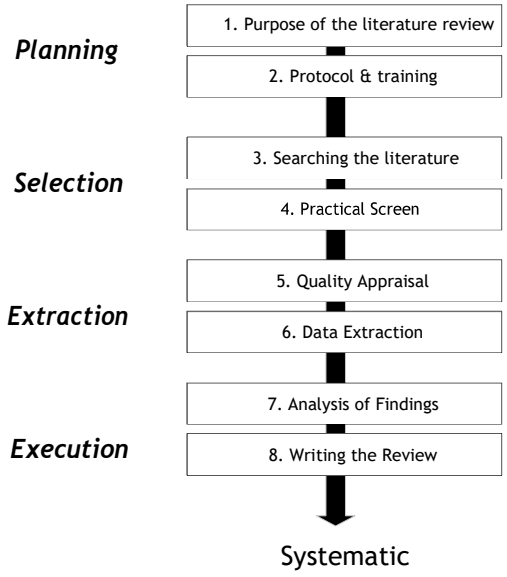

Figure 1. Systematic Literature Review methodology adapted from Chitu Okoli and Kira Schabram (2010).

1. *Purpose of the literature review*: As this paper aims to identify and understand factors affecting IoT adoption in FSCM, a literature review is conducted for the purpose of exploring the factors of IoT adoption in supply chain management in general, through existing studies and research papers of pertinent topic. The existing significant factors would then be adjusted to fit the context of FSCM considering that the food supply chain is distinctive in several aspects from other supply chains in general. The adjustment is framed based on the food properties which are not applicable to supply chain managements other than FSCM.
2. *Protocol*: In the execution of the literature review, we as the authors, as well as the reviewers, are in one agreement to follow a clear and detailed procedure that has been organized together through prior comprehensive discussion. For every paper reviewed, each reviewer must document literature identity including title, authors, year, journal of publication, publisher, and DOI; summary of the literature body including research problem, factors, methodology/design/approach, and results; and also remarks from the reviewer including objective assessment and highlighted part or idea of the literature.

The documentation of the literature review is then shared between each reviewer and discussed together in order to ensure that the protocol is carried out appropriately and the respective literature is eligible to be used in this study.

3. *Searching the literature*: Since the concept of IoT application is still recent in supply chain (Ben-Daya et al, 2017), the literatures used in this study are collected from global online databases. We searched the literature carefully by inputting the combination of keywords 'food supply chain', 'Internet of Things', 'supply chain management', and 'disruptive technology' in the search box of the database. In this review, we considered the papers from the search result that address the food supply chain management and the IoT or disruptive technology in supply chain explicitly such as the trends of food supply chain management and the impact of IoT application on the supply chain.
4. *Practical screen*: In the execution of initial screening process, the literature obtained from the searching process is set to be eligible if it is published within the last 10 years and comes from reputable journals and publishers. The selected paper from the initial screening is then further assessed by the reviewer through its abstract, methodology, and final result to determine whether the paper is relevant and can be used as a reference for this study. Once the paper succeeded the second screening, we would proceed with the paper for a deep and full reading.
5. *Quality appraisal*: After conducting the deep and full reading, we excluded several papers that do not provide either the implications of food supply chain management or the implications of IoT adoption in supply chain as the necessary data for this study. For example, a paper that studies about the intelligent container for food logistics did reasonably satisfy the criteria of addressing both the food supply chain and the use of disruptive technology in it. However, when the deep and full reading of the said paper found that it only focused on the container's field tests and did not talk about any implication of IoT adoption in it, we decided to exclude this paper. For this reason, we finally selected 45 peer- reviewed papers qualified for this study, out of 87 papers obtained from the practical screen process.
6. *Data extraction*: The applicable information bound to be extracted from the 45 selected papers is the implication of IoT adoption factors in supply chain. We extracted the data by generating the list of considerable factors from each of the papers. The extraction findings showed that the factors vary in terms of context and approach used in the study.
7. *Analysis of findings*: The findings from the data extraction are analyzed by means of grouping the similar factors under a single concept of keyword. For example, external pressure and government policy are to group within the factor of peers and government support. Afterwards, with the list of grouped factors, we attempted to find the correlation between the food properties and the factors so that the important factors affecting IoT adoption can be used in the context of FSCM.
8. *Writing the review*: The review from the SLR processes as described per step above is written in the form of this research paper. The results of the review are reported as sufficiently detailed as possible in the following result and discussion section. Then, based on the literature review, this paper proposed a framework of factors affecting IoT adoption in FSCM that may be used for future studies.

3. RESULT AND DISCUSSION

3.1 Literature Review Result

In this section, we report the findings from SLR of 45 peer-reviewed papers in a summarized list of significant factors along with the authors whose related study supported and implied the idea of the factors. Some papers might address several factors at once, while some others addressed only one specific factor.

Table 1. Summary of significant factors affecting IoT in supply chain management.

List	Author (Year)	Number of Publications
Performance perceived benefit	Abdallah Jamal Dweekat et al. (2016), Abubaker Haddud et al. (2017), B. Tjahjono et al (2017), Bing Jia and Yongjian Yang (2011), Bo Yan et al. (2017), C. N. Verdouw et al. (2016), Cheng Zhang and Jasbir Dhaliwal (2009), Danping Lin et al. (2016), de Vass et al. (2018), Feng Tian (2017), Florian Kache and Stefan Seuring (2017), Fu Ying, Li Fengquan (2013), Habibullah Khan and Joel D. Wisner (2019), I-Hsuan Hong et al. (2011), Irene Ng et al. (2015), Krzysztof Witkowski (2017), Li Da Xu (2011), Li Da Xu et al. (2014), Lou Ping et al. (2011), M. Abdel-Basset et al. (2018), M. Bourlakis and A. Matopoulos (2010), M. Obal (2017), Marcel Papert and Alexander Pflaum (2017), Marian Carcary et al. (2018), Mengru Tu (2018), Murray A et al. (2016), Myo Min Aung and Yoon Seok Chang (2014), Pattrick Dittmer et al. (2013), Riccardo Accorsi et al. (2017), Shancang Li et al. (2014), Yingfeng Zhang et al. (2016), Yu Gu and Tiaobin Jing (2011), Zhi Li et. al (2017), Zhibo Pang et al. (2015)	34
Hardware and infrastructure	Abubaker Haddud et al. (2017), Bing Jia and Yongjian Yang (2011), C. N. Verdouw et al. (2016), Danping Lin et al. (2016), Feng Tian (2017), Florian Kache and Stefan Seuring (2017), Fu Ying, Li Fengquan (2013), Li Da Xu (2011), Lou Ping et al. (2011), Marcel Papert and Alexander Pflaum (2017), Pattrick Dittmer et al. (2013), Riccardo Accorsi et al. (2017), Shancang Li et al. (2014), Zhi Li et. al (2017), Zhibo Pang et al. (2015)	15
Cost	Abubaker Haddud et al. (2017), Bo Yan et al. (2017), C. N. Verdouw et al. (2016), Danping Lin et al. (2016), Florian Kache and Stefan Seuring (2017), In Lee and Kyochun Lee (2016), Li Da Xu et al. (2014), M. Obal (2017), Mengru Tu (2018), Muhamad Suryanegara et al. (2018), Myo Min Aung and Yoon Seok Chang (2014), Yingfeng Zhang et al. (2017), Zhi Li et. al (2017), Zhibo Pang et al. (2015)	14
Security and privacy concern	C. N. Verdouw et al. (2016), Ching-Wen Hsu et al. (2017), Florian Kache and Stefan Seuring (2017), Frederick J. Riggins and Samuel Fosso Wamba (2015), In Lee and Kyochun Lee (2016), Li Da Xu (2011), Li Da Xu et al. (2014), M. Abdel-Basset et al. (2018), Marcel Papert and Alexander Pflaum (2017), Marian Carcary et al. (2018), Muhamad Suryanegara et al. (2018), Shancang Li et al. (2014), Zhibo Pang et al. (2015)	13
Adoption willingness	Bo Yan et al. (2017), C. N. Verdouw et al. (2016), Danping Lin et al. (2016), Krzysztof Witkowski (2017), M. Obal (2017), Muhamad Suryanegara et al. (2018), Yingfeng Zhang et al. (2017), Zhibo Pang et al. (2015)	8
Data complexity	Abubaker Haddud et al. (2017), Danping Lin et al. (2016), In Lee and Kyochun Lee (2016), Li Da Xu (2011), Marian Carcary et al. (2018), Shancang Li et al. (2014), Zhibo Pang et al. (2015)	7
Peers an d government support	Cheng Zhang and Jasbir Dhaliwal (2009), Ching-Wen Hsu et al. (2017), Danping Lin et al. (2016), I-Hsuan Hong et al. (2011), M. Obal (2017), Mengru Tu (2018)	6
Technical knowledge	Danping Lin et al. (2016), In Lee and Kyochun Lee (2016), Marcel Papert and Alexander Pflaum (2017), Shancang Li et al. (2014), Zhibo Pang et al. (2015)	5

Compatibility	Abubaker Haddud et al. (2017), Danping Lin et al. (2016), Marian Carcary et al. (2018), Muhamad Suryanegara et al. (2018)	4

The nine important factors are put in descending order based on the number of publications addressing each factor on the implication of IoT adoption in supply chain management. Each factor is described in the following explanation.

1. Performance perceived benefit

Researchers and practitioners are in one agreement that IoT-enabled supply chain gains more benefits including real-time information sharing, cost reduction, efficiency, transparency, traceability, and sustainability, than the one lagging disruptive technology. IoT-enabled supply chain performs in a way that increases company's productivity and competitiveness in the market. Accordingly, the performance perceived benefit has been a major affecting factor for a company to adopt IoT in its supply chain management. The higher supply chain performance benefit is perceived by a company, the more likely it is to adopt IoT.

2. Hardware and infrastructure

Potential IoT adopters are still concerned by the hardware and infrastructure needed to deploy IoT technology in their supply chain management. IoT adoption must be followed by the complete provision of tools, protocols, applications, and connectivity to establish the environment that facilitates information sharing among all involved stakeholders. This affects the companies' adoption intention on the base of whether they could afford to build and maintain such an IoT environment. Numbers of existing studies have designed and suggested various IoT architectures to support the supply chain management, indicating how hardware and infrastructure are an important factor to be considered in IoT adoption, especially at the industry level.

3. Cost

The cost of adopting IoT remains a top challenge for the industry, making it another vital factor to be considered. IoT adoption needs not only cost for installment, but also for establishing the facilitating environment as mentioned above in factor number two as well as its maintenance. Findings from SLR implied that the economic dimension of IoT adoption should be considering the cost-benefit analysis on the base of whether the spent cost is worth the benefit it would bring in return, indicating that cost is an important factor for a company to adopt IoT in supply chain management.

4. Security and privacy concern

Several studies found in SLR showed that some barriers to IoT adoption at industry level are including the insufficiency of willingness to share information and the doubt regarding data security and reliability. These findings signified how security and privacy become an affecting factor in adopting IoT. Prior to adoption, the company needs to have enough understanding about the security and privacy concern along with the risks when IoT is deployed within its supply chain management.

5. Adoption willingness

Company's willingness plays a fundamental role in the decision to adopt IoT technology. The level of willingness remarkably relies on the other factors as it is higher when the other factors show signs of favor to the adoption of IoT itself. For instance, a company generally is more willing to adopt IoT technology when the device cost and electricity bill decrease, as some studies conveyed. However, if the company has no intention to deploy IoT at all regardless the other supporting factors, then IoT adoption in supply chain management is more likely to not occur, marking it as another important factor for a company.

6. Data complexity

IoT emerges as a data-driven technology that involves a vast data processing throughout its

usage. Depending on the type, some IoT technologies indeed engages in a complex data dealing that requires not only skilled and knowledgeable users, but also facilitating conditions in terms of data management such as tools and networks. Findings from past studies show that data complexity matters as a challenging barrier to IoT adoption in supply chain management, for the company might concern the affordability to handle the complex data throughout the whole supply chain.

7. Peers and government support

Peers and government support refer to the company's facilitating condition, either in tangible or intangible form, that is received from external parties including business partner, government regulation, as well as social competitiveness. It is found that the pressure from the external parties impacts positively on the company's willingness to adopt IoT, from the fact that suppliers are more likely to adopt IoT when their enterprises in partnership are using it. Overall, peers and government support determine how IoT technology is going to be deployed throughout the supply chain in terms of conduct and measure.

8. Technical knowledge

Technical knowledge is in the scope organizational dimension that is also no less of importance as it backs and determines the success behind IoT deployment once the company decides to adopt it. Past studies found that the shortage of competent personnel on the use of new technology is one of the company's barriers to adopt IoT, indicating that technical knowledge is another important factor to be considered. Following IoT adoption, a company must strive to ensure all involved users are competent enough to work using it.

9. Compatibility

Compatibility, also known as interoperability, refers to how well the adopted technology can blend in the entire company system. It is found that companies typically concern about whether IoT can work well with their business process, strategic management, supply chain flow, as well as preceding information systems. In this case, standardization of the operation on the use of IoT across all involved users and tools is a matter that must be paid attention to by the company before adopting IoT.

3.2 DISCUSSION

Based on the findings from SLR, it is evident that a company generally should consider performance perceived benefit, hardware and infrastructure, cost, security and privacy concern, adoption willingness, data complexity, peers and government support, technical knowledge, and compatibility on the decision to adopt IoT in its supply chain management. However, when it comes to FSCM, these factors would entail an adjustment in respect of the inherent food properties, primarily food quality and food adulteration. This concept is also supported by the study from Myo Min Aung and Yoon Seok Chang (2014) that brought up both quality and adulteration as the paramount aspects in the industrial food chain. IoT emerges as a smart, disruptive technology which does not just enable the traceability of food production along the entire supply chain in terms of product identification and processing from origin factory to end customer, but also along the entire product lifecycle for quality and adulteration as they impact on people health (Lucia Ramundo et al, 2016).

4. CONCLUSION

In this paper we presented the results of a Systematic Literature Review (SLR) on the significant factors affecting IoT adoption in supply chain management, where the result could be used for further understanding to fit the context of Food Supply Chain Management (FSCM). It is worth noting that the general IoT adoption factors in supply chain management remain applicable in FSCM, yet they must be correlated with the distinctive food properties, mainly food quality and food

adulteration. This paper offers insights that could be useful for academia to direct a future study and for industrial practitioners to plan a smarter FSCM. Finally, we will conduct a follow-up study in the future by surveying food companies in Indonesia to further analyze as well as validate the findings of this research.

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