

Antecedents of Supply Chain Technology Adoption: A Theoretical Framework and Future Directions

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Abstract - In today's dynamic business environment, supply chain is a crucial part of business operations. Technologies play an important role in the success of the supply chain. Although the technology is widely used in many industries, but the adoption of SCT for SMEs is limited. The objectives of this study are to identify the factors affecting SCT adoption, determines the relationship between the factors affecting the adoption of SCT and identify the types of technologies used by SMEs in Malaysia. Previous studies used only a limited viewpoint approach to SCT adoption. Thus, the researcher proposed an integration model based on Diffusion of Innovation (DOI) and Technology-Organization-Environment (TOE) theory to explore the determinants that affect the adoption intention of SCT. This study will employ a quantitative approach. Data will be collected through a questionnaire on the SMEs in Klang Valley, Malaysia. It will be analyzed using Structural Equation Modelling (SEM) via partial Least Square (PLS). The results will contribute to a better understanding of the determinants affecting SCT adoption among SMEs in Malaysia subsequently can lead to improved business performance with the utilization of the SCT.

Keywords- Diffusion of Innovation (DOI), Supply Chain Management (SCM), Supply Chain Technology (SCT), Small and Medium Enterprises (SMEs), Technology Organization-Environment (TOE)

I. INTRODUCTION

Supply chain technology is an important element for the success of the company. Investing in technology and sustainability considerations in the supply chain will be key elements that will affect the organization's performance. In general, when reviewing supply chains in Malaysia, developments in technology and sustainability should also be taken into account. Based on the current situation, for SMEs in Malaysia, the COVID-19 pandemic has shown a huge impact in terms of ways businesses can continue to effectively communicate and manage within a remote working environment, which many organizations are likely to leverage going forward. In fact, businesses with a stronger digital infrastructure have done better than those without in the COVID-19 pandemic.

It is currently evident that the rapidly changing global competitive environment makes it a major challenge for SMEs to create and maintain competitive positions. Therefore, to improve their performance and increase productivity levels, SMEs need to highlight effective and efficient strategies that can be facilitated by the use of

technologies that help them gain a competitive advantage. Over the years supply chain scholars and research have focused on introducing supply chain technologies specifically into manufacturing practices. At the moment, the factors that will facilitate the adoption of SCT by SMEs are still unclear. Therefore, to encourage the growth and widespread adoption of SCT among SMEs in Malaysia, the factors influencing SCT adoption should be identified. Despite the growing interest in the SCT among practitioners and academicians, the SCT literature is still limited and terse. Therefore, this paper attempts to determine the internal and external antecedents that affect the adoption of SCT among SMEs in Malaysia. In addition, the purpose of this paper is to develop a theoretical framework to enhance the knowledge and understanding regarding the antecedents of SCT adoption. This study proposed an integration model based on Diffusion of Innovation (DOI) and Technology-Organization-Environment (TOE) theory to explore the determinants that affect the adoption intention of SCT among SMEs in Malaysia. It is hoped that this paper will provide valuable insight into the adoption of SCT in SMEs to further leverage the benefits of the technology for their business.

This paper contains four parts. First, the existing literature on supply chain management and supply chain technology is reviewed. Secondly, the integration model based on Diffusion of Innovation (DOI) and Technology-Organization-Environment (TOE) theory to explore the determinants that affect the adoption intention of SCT is reviewed. In the third section, the proposed theoretical framework is then developed. Finally, research contributions and several recommendations for future research were discussed in this paper.

To date, prior studies have focused on introducing supply chain technologies specifically into manufacturing practices. Previous studies focus more on the textile industry, automotive, and manufacturing whilst overlooking the determinants of SCT adoption in SMEs. Research on the antecedents of SCT adoption is still lacking and the understanding also remains scarce. Hence, there is a need for the researcher to expand the understanding and knowledge of SCT adoption particularly SMEs in Malaysia generally [7]. Therefore, this study attempts to: 1) Identify the factors affecting SCT adoption; 2) Determine the relationship between the factors affecting the adoption of supply chain technology; and 3) Determine the types of technologies used by SMEs in Malaysia.

II. CURRENT ISSUES FOR SMEs IN MALAYSIA

Small and medium-sized enterprises (SMEs) are considered an important backbone of an economy as they play an important role in developing countries [1]. The definition of SMEs differs depending on the industry. Generally, it is based on the two criteria which include the sales turnover and number of full-time employees. For the manufacturing sector, SMEs are defined as companies with a turnover of no more than RM 50 million OR a number of full-time employees of no more than 200. For the service and other sectors, SMEs are classified as companies with a maximum turnover of RM 20 million OR a number of full-time employees up to 75.

The development of micro, small and medium-sized enterprises (SMEs) is always a high priority for the government as they account for 98.5% of business start-ups and contribute 38.9% to gross domestic product (GDP) in 2019. The Malaysian government has allocated a budget of RM 2.65 billion to improve digitization, technology and innovation for SMEs [2]. It has been proven that SMEs with embedded technology can last for the long term, especially in times of crisis like the COVID-19 pandemic. The introduction of technology will help bridge the productivity gap between SMEs and large companies by improving the capacities and skills for competitiveness and innovation.

In addition, according to [3] adopting supply chain technology has been shown to improve supply chain reliability, increase supply chain responsiveness, improve supply chain agility, minimize supply chain costs, and improve asset management. Based on the [2], it was reported that not many SMEs recognize the possibilities of technology digitization. Looking at the current world scenario, the pace of digitization is increasing and there is a need for SMEs to accelerate the adoption of technologies to increase their future growth.

III. LITERATURE REVIEW

A. Supply Chain Management

According to [4], supply chain management is a complicated network that not only deals with the flow of goods, finance and information but also includes inventory management, planning and customer satisfaction. Without proper supply chain planning, it can disrupt the entire organizational system and ultimately disrupt not only companies but also the country's economy. In addition, supply chain management describes the systemic and strategic coordination of business functions within the entire supply chain to sustainably improve the performance of the individual companies and the supply chain as a whole [5]. Supply chain success requires effective and efficient management and technology. The supply chain network consists of suppliers, manufacturers, distributors, wholesalers, retailers and customers. All of these networks must be supported by three main pillars, namely business processes, organizational structures and technologies [6]

B. Supply Chain Technology Adoption

Supply Chain Technology (SCT) is a tool that helps improve the effectiveness and efficiency of the supply chain, making it a competitive weapon for corporate strategy [7]. According to [8], the previous studies on technology adoption have aimed at understanding, predicting, and explaining variables that influence adoption behavior on both an individual and organizational level to accept and leverage technological innovations. SCT refers to a technology for coordinating and integrating the flow of information electronically throughout the supply chain network. The chain includes trading partners and customers in both directions to generate effective and efficient business transactions, quick access to information, better customer service, less paperwork, better communication, higher productivity and time savings. [9]

Supply chain technology is one of the technologies that are beneficial to the industry in improving performance [3]. Technology plays a critical role in helping supply chains meet the challenges of an ever-changing environment and multiple risks at all levels. In addition, the technology has had a major impact on the structure of supply chains due to its ability to integrate various processes internally and especially external integration with suppliers and customers. The benefits of technology in a supply chain include improving communication, collecting and transmitting data to and from suppliers and customers, enabling effective decision-making, improving productivity, and improving supply chain performance. [10]

Currently, the position of supply chain technology has grown not only in manufacturing but also in the smooth running of the upstream and downstream supply chain. Therefore, understanding and practice of adopting supply chain technologies have become a critical requirement to stay competitive in the world market [11]. According to [12] asserted that technological advances have changed the way people communicate and share information. This novel technology will have an impact on the logistics, supply chain, manufacturing, and transportation industries. Therefore, the future of every industry is opened to innovation and technology. Every industry is going through a rapid change that began with the fourth industrial revolution.

In summary, supply chain technology can help improve the overall performance of the company's supply chain. Benefits include improved supply chain reliability, responsiveness, agility, cost, and asset management. In addition, it will expand the ability of the organization to operate more effectively and efficiently in the global competitive environment. As a result, companies need to deploy appropriate supply chain technologies to achieve higher performance in the future [3].

The types of technologies referred to for this study are listed in Table 1 and have been identified as SCT by previous researchers.

TABLE I
 TYPES OF SUPPLY CHAIN TECHNOLOGY

Source	Supply chain technology
National Entrepreneur and SME Development Council (NESDC) [2]	5G/6G, Sensor technology, 4D/5D printing, Advanced materials, Advanced intelligent systems, Augmented analytics and data discovery, Blockchain, Neurotechnology, Bioscience technology, Robotic, Manufacturing technology, Electrical and electronics, Cybersecurity and encryption and Drones
G. Büyükoçkan and F. Göçer [13]	Augmented Reality (AR), Big Data (BD), Cloud Computing (CC), Robotics (R), Sensor Technology (ST), Omni Channel (OC), Internet of Things (IoT), Self-Driving Vehicles (SDV), Unmanned Aerial Vehicle (UAV), Nanotechnology (N) and 3D Printing (3DP)
M. Tu [14]	Electronic product code (EPC), RFID, Barcode, EDI, IoT system, Enterprise resource planning (ERP) Manufacturing execution system (MES) and Customer relationship management (CRM)
K.-L. Lee, M. G. Hassan, and Z. M. Udin [3]	Bar-Coding, CAD, CRM, EDI, ERP, Extranets, Internet, Intranet, MRP, RFID, SRM, Wireless/ Mobile Devices
H. Gangwar, H. Date, and A. D. Raoot [8]	Internet, e-commerce, ERP, RFID, EDI, and knowledge management
N. K. Kamaruddin and Z. M. Udin [9]	CAD, Bar-coding technology, DFM, PDM, WMS, AQC, TMS, e-Commerce, CRM, ERP SCP, MES, SCE, and RFID

C. Diffusion of Innovation (DoI) theory

The theory of diffusion of innovation is used as the underpinning theory for this study. The DoI theory is considered one of the oldest theories in the social sciences, developed by Rogers in 1962. According to [15], there are four main elements involved in diffusion of which include innovation, communication channels, time, and the social system. Previous research by [16] found that innovation diffusion theory has been widely used to study user acceptance of innovation in many sectors such as agriculture, sociology, information systems, manufacturing, and others.

Diffusion refers to the process by which an innovation is communicated through certain channels over time between the members of a social system. It is considered a special type of communication because the messages are new ideas. Communication is a process in which participants create and exchange information to achieve mutual understanding between two or more parties [15].

In diffusion studies, according to [9], adoption is often seen as a dependent variable. Adoption is a component of the dissemination process that relates to the trial use of the innovation and the decision to continue

using the innovation. In addition, it is rolled out when the organization decides to invest in innovating its processes [9]. [15] has conceptualized five main steps in the innovation-decision process. Among the steps are knowledge, persuasion, decision, implementation and confirmation. Likewise, [17] also stated there are five stages in technology adoption of which include knowledge, persuasion, decision, implementation and confirmation stage. Each stage has a different process of innovation diffusion.

A previous study conducted by [9] emphasized that knowledge is seen as the first stage in acquiring technology information. The second phase is persuasion, where the persuasion phase is to adopt the technology, while the third phase is a decision where the organization either decides to accept or reject the technology. The fourth stage is implementation. At this stage, the organization begins to implement the technology and use it effectively. Finally, the fifth stage in which the confirmation stage exists. The organization must evaluate the outcome of the use of the technology to recognize the efficiency and effectiveness of the technology. According to [18], based on the review of the technology adoption literature, they argue that most models are derived from both Diffusions of Innovation (DOI) theory and the TOE framework.

Technological factors (Internal antecedents)

According to [19], the technological factors explained the characteristics and availability of the technology apply to an organization with regards to the technological competence and its perceived benefits. The variables include perceived cost, perceived compatibility, perceived ease of use, perceived usefulness, and perceived complexity.

1) Perceived cost

Other researcher [20] emphasized that perceived costs relate to all expenses for the use of necessary technologies for all transactions and efforts to increase the efficiency of the processes involved and also include the costs for other supporting software, hardware, and employee training. The perceived cost could be an obstacle to adopting the technology. Furthermore, previous research by [21] stated that although the cost was believed to be one of the main barriers to technology adoption, some researchers argued that cost might motivate users to embrace innovative technologies in their business to make production cost-effective. The lower the cost of adoption will lead to the higher new technology innovation adopted by the organization and vice versa [22].

2) Perceived compatibility

[15] refers to compatibility as the degree to which an innovation is perceived as being in line with the existing values, experiences, and needs of potential users. The perceived compatibility between new and established technologies has a significant impact on adoption; adoption is faster when new technologies offer compatibility and integration [23].

3) *Perceived ease of use*

Perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of effort." This degree to which a person believes that using a particular system would be free of effort [24]. A previous study by [22] indicated that when the appropriate skills and understanding of the technology are in place, the technology is easier to use and therefore more likely to be accepted by users.

4) *Perceived usefulness*

Perceived usefulness refers to "the extent to which a person believes that using a particular system would enhance his or her job performance." People tend to use or not apply an application to the extent they believe it will help them perform their job better. This is called perceived usefulness [24]. Perceived usefulness has been widely used in technology adoption studies. It is considered a consistent innovation feature and was the most strongly correlated factor in technology diffusion [6].

5) *Perceived Complexity*

According to [15], complexity refers to the degree to which an innovation is perceived as difficult to understand and use. Therefore, some innovations in an organization are easily understood by most members of a social system; others are more complex and slower to adopt. Likewise, [22] stated that most of the previous studies show that the more complex new technology is perceived to be, the less likely it will be adopted. In addition, [15] also stated that complexity correlates negatively with the adoption rate. Hence, the excessive complexity of an innovation is the most important drawback in its adoption decision. Prior research found that complexity had a negative influence on new technology adoption decisions [20].

Complexity was highlighted as the unpredictable response of the system to give the user a range of inputs. In other words, complexity focuses on the challenges of understanding, handling, and using a complex technology in all processes [25]. According to other researchers [6] stated that when complexity arises, users have to put in extra effort and use more features to support their job performance. There is agreement that the more complex the system, the greater the effort. Therefore, the perceived complexity is negatively related to the adoption of supply chain technology. Furthermore, the complexity of the tasks has a positive effect on technology acceptance; when tasks are complex, companies tend to adopt technologies that can simplify them and make them less complex [23].

Organizational Factors (Internal antecedents)

1) *Quality of human resources*

In an organization, factors such as the knowledge, skills, and attitudes of employees influence whether the new technology is accepted or rejected. In addition, employees do not have the same skills, knowledge and experience to use the new technology. If they lack this

knowledge and skills in technology, they are less likely to adopt new technological innovations. Therefore, the quality of human resources has a positive effect on technology acceptance in the organization [20]. According to [21], The organization needs to provide extensive training for its employees to fill the knowledge gap and improve their skills and knowledge to better understand the underlying technological innovation.

2) *Top management support*

Top management support refers to the level of commitment and resource support from top management to the new technology. For an organization, the successful adoption and implementation of technological innovations depend heavily on the support of top management. The support of top management has a positive effect on the adoption of technology [20]. In addition, top management support is one of the organizational factors that are important when adopting supply chain technology. This factor can be seen as an important factor in technology diffusion. [25]. A previous study conducted by [21] stated that top management support has a huge impact on the adoption of innovative technologies. For SMEs, the owners or managers are the top management who play an important role in every decision-making process in the organization.

In addition, top management support has been identified as the most important variable in implementing technology, as it is vital to provide planning, guidance and support in terms of sufficient funding for training and technical assistance that can lead to successful operations. Hence, there is a positive relationship between top management support and supply chain technology adoption. [6]. Likewise, this is supported by [23], the organizations with strong support from top management are more likely to adopt new technologies faster than those without such support.

3) *Company size*

Other researchers show that company size influences the adoption of SCT. In addition, the study shows that small and medium-sized businesses face unique problems compared to larger companies, including limited financial resources, low labor skills and minimal strategic management in adopting the technology. It is hypothesized that larger organizations are more likely to adopt SCT technologies compared to smaller organizations due to small businesses suffer from resource poverty.[9]. According to [23] the large companies are more likely to adopt new technologies faster than small ones.

D. Technology-Organization-Environment (TOE) theory

TOE framework explains how the business context affects the adoption and implementation of technological innovations. TOE framework is synonymous with Rogers's DOI theory. The combination models of the TOE framework and DOI theory have been used in

various disciplines to demonstrate their theoretical strength, empirical support and effectiveness in investigating the readiness, adoption and deployment of various forms of technology innovations [20].

The TOE framework is in line with the DOI theory, in which the DOI theory emphasizes the individual characteristics and both internal and external characteristics of the organization as drivers for the innovative strength of the organization. Therefore, these are similar to the technology and organizational factors of the TOE framework, but the TOE framework also includes an additional factor which is the environment. The TOE framework makes Roger's innovation diffusion theory better able to explain innovation diffusion within companies. [19]. Based on the comparisons of the theoretical model, this study integrates the DOI and TOE models, which were both empirically validated in the previous studies [21]. In addition, [19] stated that the TOE framework identifies three aspects of an enterprise's context that influence the process by which it adopts and implements a technological innovation: technological context, organizational context, and environmental context

A previous study conducted by [18] found that most of the empirical studies on technology adoption come from the DOI theory and also from the TOE framework. Since the TOE framework includes the environmental factor (not included in the DOI theory) it is useful to explain the adoption of innovations within the company. Hence, the model can be seen as comprehensive. The TOE framework also has a solid theoretical foundation, consistent empirical support, and potential application for technology adoption.

Environmental factors (External antecedents)

1) Customer acceptance

A previous researcher [17], customer acceptance and trust are crucial for the further development of any new technology in the company. In addition, customer acceptance is very important for the successful implementation of new technology. Thus, it is proven that the characteristics of the technology play a crucial role in determining whether or not the people involved in the activity will use it. Therefore, understanding customer perception of the adoption of new technology could help facilitate the further growth of the implementation of that particular technology. Furthermore, the study also found that the organization can develop a great technology and application, but when customers do not use it, the implementation has failed. Therefore, customer acceptance is an indisputable key to any further implementation and development of any technology and application [17].

2) Government support

According to [21], government support has been identified as an environmental element that has an impact

on the introduction of technological innovations. By using a specific regulation, the government can discourage and encourage the innovation adoption of the technology in companies. In addition, the existence of normative constraints has a positive effect on technology adoption; when pressure from customers, legal entities, governments, trading partners, and others is high, adoption becomes faster [23]. Government support has been identified as an environmental element that has an impact on the adoption of technological innovations in an organization [21]. Based on the study conducted by [19], stated that government regulation can have either a positive or negative impact on innovation.

IV. PROPOSED THEORETICAL FRAMEWORK

TOE framework is synonymous with Rogers's DOI theory in an organization. The combination models of the TOE framework and DOI theory have been used across various disciplines [20]. The proposed theoretical framework is shown in Figure 1 below. This study integrates the DOI and TOE theory to examine the influence of technological, organizational and environmental factors that affect intention adoption of supply chain technology among Malaysian SMEs.

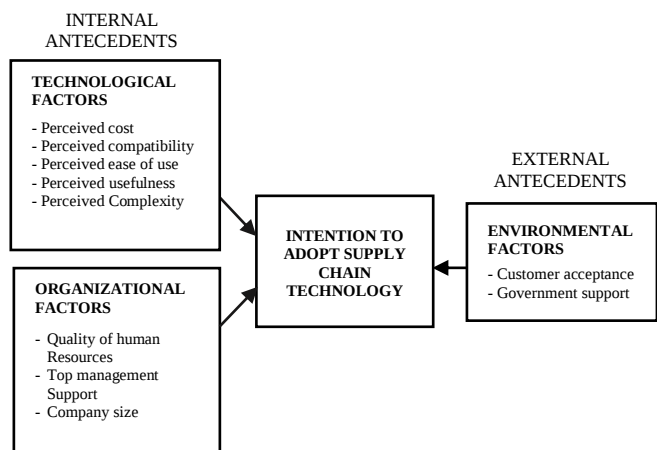


Figure 1: Proposed Theoretical Framework.

Generally, based on the theoretical framework, the following propositions are proposed:

- Perceived cost has a significant positive effect on the intention to adopt supply chain technology.
- Perceived compatibility has a significant positive effect on the intention to adopt supply chain technology.
- Perceived ease of use has a significant positive effect on the intention to adopt supply chain technology.
- Perceived usefulness has a significant positive effect on the intention to adopt supply chain technology.
- Perceived Complexity has a significant positive effect on the intention to adopt supply chain technology.
- Quality of human resources has a significant positive effect on the intention to adopt supply chain technology.

- Top management support has a significant positive effect on the intention to adopt supply chain technology.
- Company size has a significant positive effect on the intention to adopt supply chain technology.
- Customer acceptance has a significant positive effect on the intention to adopt supply chain technology.
- Government support has a significant positive effect on the intention to adopt supply chain technology.

VI. METHODOLOGY

The study begins from identification of problem or issue associated to the supply chain technology adoption in Malaysia. Subsequently, the problem statement is translated into the research objectives. This study will adopt a cross-sectional and quantitative approach questionnaire survey as a mean for data collection. The target respondents are from managerial level and above or those who in-charge with the knowledge and information related with this study. A survey questionnaire will be made with suitable modifications from previous studies to a better understanding of the determinants affecting SCT adoption among SMEs in Malaysia. Data will be collected through a questionnaire on the SMEs in Klang Valley, Malaysia. It will be analyzed using Structural Equation Modelling (SEM) via partial Least Square (PLS). The recent listing of SMEs in Malaysia will be gathered from SME Corporation Malaysia. The research flow is illustrated by Figure 2.

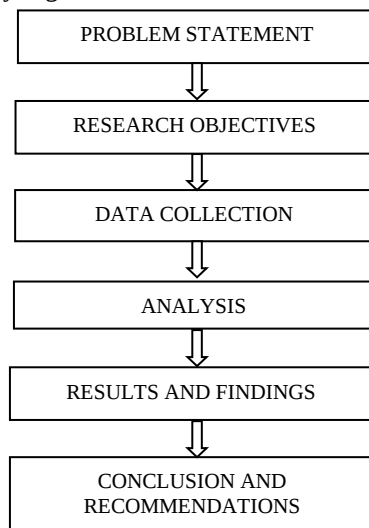


Figure 2: Research Flow

V. CONCLUSION

Nowadays, supply chain technology adoption is crucial for the success of the organization. Its gives huge impacts on business performances. Thus, the objectives of this study are to identify the factors affecting SCT adoption, determines the relationship between the factors affecting the adoption of SCT and the types of technologies used by SMEs in Malaysia. The present study is designed to develop a theoretical framework that

ascertains the antecedents of the intention adoption of supply chain technology for Malaysian SMEs. Since this study only applies a theoretical perspective on the integration model based on the DOI and TOE theory to determine the factors influencing the adoption intention of SCT, future research should provide extensive literature and understand the concepts through case studies or empirical research as well as the practice of qualitative or quantitative methods to acquire comprehensive theoretical knowledge. In conclusion, it is hoped that this study can be a guide for organizational practice and supply chain practitioners, especially Malaysian SMEs, to adopt SCT for the benefits of their businesses. In addition, this study will provide valuable insight into the adoption of SCT in SMEs to further leverage the benefits of technology for the better growth of their business in future. Additionally, this study could provide a good platform for researchers and academics to conduct research into the supply chain field, particularly regarding technology adoption in Malaysia generally.

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