Journal of Marine Science and Technology

Volume 28 | Issue 4 Article 1

AN ANALYSIS OF KEY FACTORS INFLUENCING INTEGRATION OF BLOCKCHAIN INTO SHIPPING COMPANIES IN TAIWAN

Tien-Chun Ho
Dept. of Shipping and Transportation Management, National Penghu University of Science and Technology. Penghu, Taiwan, R.O.C., htc0220@gms.npu.edu.tw

Chien-Lung Hsu
Dept. of Business Administration, University of Kang Ning, Taipei, Taiwan, R.O.C.

Recommended Citation

Ho, Tien-Chun and Hsu, Chien-Lung (2020) "AN ANALYSIS OF KEY FACTORS INFLUENCING INTEGRATION OF BLOCKCHAIN INTO SHIPPING COMPANIES IN TAIWAN," *Journal of Marine Science and Technology*: Vol. 28: Iss. 4, Article 1.
DOI: 10.6119/JMST.202008_28(4).0001
Available at: https://jmstt.ntou.edu.tw/journal/vol28/iss4/1

AN ANALYSIS OF KEY FACTORS INFLUENCING INTEGRATION OF BLOCKCHAIN INTO SHIPPING COMPANIES IN TAIWAN

Acknowledgements

The authors thank the Ministry of Science and Technology, Taiwan, R.O.C. for providing financial supports (MOST107- 2410-H-451-001).

Journal of Marine Science and Technology, Vol. 28, No. 4, pp. 229-236 (2020)
DOI: 10.6119/JMST.202008_28(4).0001

AN ANALYSIS OF KEY FACTORS INFLUENCING INTEGRATION OF BLOCKCHAIN INTO SHIPPING COMPANIES IN TAIWAN

Tien-Chun Ho [1] and Chien-Lung Hsu [2]

Key words: blockchain technology, distribution center; extended fuzzy preference relation; FMCGDM; location evaluation.

ABSTRACT

The impact of blockchain technology in many industries has changed lives of people. With the advent of blockchain technology, digitizing shipping processes will become a critical element in the evolution of traditional shipping toward a continuous, intelligent, and highly efficient shipping system. Therefore, this research explores key influencing factors affecting the application of blockchain technology from the standpoint of shipping companies in Taiwan. The importance of the key factors was analyzed from survey questionnaires structured on BOCR (Benefits, Opportunities, Costs, and Risks) and the Fuzzy Analytical Hierarchy Process (Fuzzy AHP). Rooted in the results, the most important evaluation criteria are benefits, and the most important sub-criteria affecting application of blockchain technology in shipping companies is reducing bribery fraud. At last, the management implications of the results discussed in depth aimed to provide shipping companies and governing authorities of blockchain technology with a basis of future application.

I. INTRODUCTION

Globalization has changed the traditionally political and economic management model. Development of the Internet has made information technology scalable, highly diffusible, transferable, and shareable, which has had a great impact on the interaction between various entities and virtual society (Song and Chen, 2002). Blockchain technology was originally the basic technology of Bitcoin, which is essentially a decentralized database. Since September 2015, "blockchain" has become the newest topic for Financial Technology (FinTech). Their blockchain project is rapidly evolving, making its applications ubiquitous (Hackius and Petersen, 2017). Considering the principle of blockchain operation from a technical standpoint, it is regarded as a large-scale distributed ledger or a huge database built upon calculus and encryption technology. Each participant conferred on the same verification authority can connect, share, and review the constantly updated ledger through the network, effectively preventing third parties from interfering or tampering with it (Wang, 2017). This open, fair, and transparent system allows all participants to access and share information in order to build a trustworthy network (Tapscott and Tapscott, 2016).

The development of blockchain technology has been around for a long time. However, there has been little research on the utilization of blockchain in the transportation and supply chain fields (Zhao et al., 2016). With the characteristics of decentralization, transparency, openness, autonomy, anonymity, and unalterablity, blockchain technology has the potential to change logistics and supply chain industry operations and to improve business models, offering more reliable and convenient service to the transportation industry. Therefore, many foreign shipping companies are preparing to introduce blockchain technology. On the other hand, bulk shipping and container shipping companies in Taiwan are still at an early stage of blockchain technology development. Besides, there is yet no relevant research and application with this subject. As in the case with the most emerging technologies, interoperability between different blockchains and compatibility with the old systems still exist (Finextra, 2017). Although its impact on the shipping and transportation industry has not yet been determined, increasing researches invested by various industries clearly proves that it is an important and considerable trend.

Depending on the participants and different degrees of information openness, blockchain technology can generally be divided into three types: public blockchains, hybrid blockchains, and private blockchains (Siba and Prakash, 2016). First, the "public chain" is a consensus process that anyone can read, send, trade, and participate in, regarded as a completely decentralized blockchain. It is only open to particular

Paper submitted 01/20/20; revised 03/10/20; accepted 03/27/20. Corresponding Author: Tien-Chun Ho (Email: htc0220@gms.npu.edu.tw)
[1] Dept. of Shipping and Transportation Management, National Penghu University of Science and Technology. Penghu, Taiwan, R.O.C.
[2] Dept. of Business Administration, University of Kang Ning, Taipei, Taiwan, R.O.C.

individuals or entities, meaning data write access authority is only given to those within a particular organization. Secondly, data read access in a "private chain" might be either open to the outside world or limited to some extent, similar to a traditional centralized blockchain. Lastly, the "hybrid chain" is open to specific organizations, but the consensus process is controlled by pre-selected participants. It is a partially decentralized blockchain. That is, the public can access and trade without verifying transactions and issuing smart contracts, which must be approved by pre-selected participants. Although the hybrid chain is positioned between the public chain and the private chain, in essence it still belongs to the category of the private chain. Its applied field has extended to Bitcoin, Finance Internet, Vechain. Ethereum, and Maersk global supply chain systems. These experiences enable shipping companies to employ blockchains in transportation services in order to effectively improve operational efficiency, transaction security, and promote competitiveness of shipping companies in the digital age.

The main purpose of this research is to analyze key factors influencing integration and necessary of blockchain into shipping companies in Taiwan. It utilizes the concept of fuzzy numbers to effectively deal with uncertainty and ambiguity, and the Fuzzy Analytic Hierarchy Process (Fuzzy AHP) to verify the importance of key factors influencing the application of blockchain technology in shipping companies. Following this instruction, section II reviews the literature on the benefits, opportunities, costs, and risks brought by blockchain to the industry, and presents discussions. Section III describes the methodology and evaluation framework employed. Section IV presents the empirical analysis of key factors affecting the application of blockchain technology in shipping companies along with a discussion of management implications. Section V demonstrates conclusions and suggestions.

II. LITERATURE REVIEW

Although blockchain technology has the characteristics of being decentralized, transparent, open, autonomous, unalterable, and anonymous, and can bring many benefits and opportunities to shipping companies, it is still in the development stage. Yet many technical and practical obstacles need to be overcome before it is able to achieve the synergy that can increase benefits and opportunities while reducing costs and risks.

2.1 Benefits and Opportunities

The World Economic Forum's "Financial Infrastructure Outlook" indicates that classified bookkeeping technology can decrease business transaction costs, improve transaction efficiency, reduce chances of fraud, lower dependence on intermediaries, and enhance trust of both parties in the trading mechanism (Guo, 2016). Blockchain technology has several advantages and benefits, such as using categorized bookkeeping technology, rebuilding the trust mechanism of the Internet through mathematical principles, and establishing trust between participants through algorithms to achieve mutual consensus. Participants need to neither enter basic information of the other party, nor establish an intermediary or third-party agency's assurance or guarantee, making a trustworthy value exchange possible while reducing the cost of establishing such a trust mechanism (Wan et al., 2017).

The blockchain's characteristics of transparency and unalterability can ensure security of transactions (Wang, 2017). Any transaction (data) update is synchronized to the entire blockchain simultaneously. The multiple blockchain nodes contain identical categorized ledger entries. Blockchain members can review any changes to the books, and trace them in the ledger. In the light of this, each party can have absolute confidence in the integrity, reliability, and security of the records, thus generating trust in the blockchain system. Compared with existing data storage models, blockchain technology can improve the security and privacy of messages. Take sea transport for example. From the beginning of an international trade transaction to the arrival of the goods at the destination consignee, the shipment must pass through complex procedures and requires various documents before the transportation operation is successfully completed. Ensuring the accuracy of the transaction process and the documentation puts much time and money into verification, confirmation, and audit. With the rapid development of information and network technology, records have transferred from paper to digital, making the flow of information faster and more efficient (Luo, 2017).

Following the introduction of blockchain smart contract technology, records can be completed while reducing inaccuracies. Related transactions can pass through the system without spending a lot of manpower, effectively saving operating costs and intermediary costs (Davidson et al., 2016; Shrier et al., 2016). In addition, the ability to decentralize computing power avoids delays caused by a central cloud server when processing large amounts of information (Wang, 2017). Network effects are also included in the advantages of blockchain technology. As blockchain technology expands in a particular area, organizational and transaction costs can be effectively reduced through the network effects. For instance, participants in the transportation field are not limited to international trading parties, but include various suppliers in the transportation process. The more blockchain users there are the more transportation and logistics companies will be attracted to join. Simultaneously, the value and competitive advantage of blockchain technology governing body, shipping companies, and supply chain operators will be increased.

2.2 Costs and Risks

Although blockchain technology can bring benefits and opportunities to users, relevant information on talent search in Taiwan focuses mainly on enhancing recruitment and self-training. Regardless whether utilizing outsourced training, a research incentive system, on-site training, job rotation, or internal management department and technical personnel to coordinate a training program, the training cost and time required for new technology development and integration should not be underestimated (Zhang and Li, 2001). With the advancement of blockchain centralized ledger technology and increasingly fierce market competition, network effects and switching costs become critical for blockchain applications (White, 2015). Varying conversion expenditures due to economic risks, evaluation costs, learning costs, and consumer acceptance will significantly and negatively affect the user's willingness to switch to the new system (Chen et al., 2011). These conversion costs can be verified by users' acceptance and conversion to new technology (Burnham et al., 2003).

In addition to labor costs, information technology is another factor affecting the development of blockchain (Wiles, 2015). When considering Moore's law, Kryder's law, and Nielsen's law, the trend in growth rate of transistors will decrease from 2020 (White, 2015). As a result, both processor speed and storage space would not meet expectations, thus limiting blockchain development. Davidson et al. (2016) further stated that the critical point of heavy usage is indeed the core issue in blockchain development. The operating costs of blockchain are affected by the design of the blockchain mechanism for consensus, including transaction throughput, the amount of data transmitted between parties for validation, the complexity of confirming such validity, and the number of participants. Enhancing the trust of the overall blockchain network means that the nodes participating in the verification process must increase their computing power to perform complex encryption operations and optimize their network bandwidth to enlarge the amount of data transmission, thus risening the cost of resources. Conversely, if the strength of verification is weakened, its credibility may be reduced due to the increasing risk of data tampering. Therefore, operating management costs of the system must be considered in the design and evaluation of the blockchain technology application phase (Wan et al., 2017).

With the popularity of e-commerce, complaints about online transactions and fraud have rapidly increased, and hacking has become one of the risks of online transactions (Duh et al., 2002). This might lead to a website forced to cease operations, loss of transaction data, data theft, and risk of personal information leakage. Although the incidence of fraud as well as the involvement and cost of intermediaries are reduced, privacy and conversion risks are increased owing to the massive data in the blockchain (Shrier et al., 2016). However, blockchain is more secure than IoT which applies Radio Frequency Identification in aspect of transaction security and privacy protection (Kshetri, 2017). Particular cases were used to illustrate the characteristics of blockchain in terms of either manipulating transactions or even creating fake transactions. It is recommended that regulators request companies to deploy blockchains in the supply chain system to achieve its safety and economic benefits. From the perspective of privacy protection, it is emphasized that transaction stakeholders should provide human resource training and increase investment in blockchain development in order to enable smooth implementation of smart contracts with the blockchain as the framework.

At present, the rules set by the regulatory and legislative bodies are complex and contradictory, which is one of the main reasons for the limited development of blockchain controls (Lootsma, 2017). In the field of FinTech, the Payment Service Directive, a payment system that simplifies the transparency of EU market transactions, was established in 2007 in response to the financial turmoil and the development of information technology. The main risks are assessed and regulated by the supervisory agencies, and the industry can formulate policies and regulations according to the situation of their own business. In the field of international transport, intelligent contracts involving blockchain are constantly evolving, thus corresponding legal and administrative organization reform is extremely important. With the convenience caused by computerization, a new set of policy management methods is needed to effectively prevent misuse (Song and Chen, 2002).

2.3 The Fuzzy Analytic Hierarchy Process

There have been many recent studies on applying the Fuzzy AHP to shipping management. For instance, the port competitiveness is evaluated by the Fuzzy AHP according to the total weights obtained (Gao et al., 2018). The key criteria consist of port size, port location, hinterland economy, port costs, operation management and growth potential, and selection. Five competing ports were selected with respect to geographical proximity. The results showed that Kaohsiung port is the best, and Quanzhou port appears last in order.

Ding et al., (2019) empirically studied the key competency and capabilities affecting the selection of middle managers for global shipping logistics service providers (GSLSPs) by the Fuzzy AHP. Its results indicated that professional competency is the most important management competency affecting the selection of middle managers for GSLSPs. Lin et al., (2019) sought the suitability of key influencing factors by the Fuzzy AHP, considering the direction of tramp shipping companies in Taiwan. Its results could provide an important research reference for outsourcing strategies of tramp shipping companies.

2.4 Comprehensive Discussions

Blockchain has become a trending issue in recent years. With the growth and application of new technologies, the evolution of blockchains in the field of transport and logistics becomes more stable gradually. Previous discussions on blockchain technology has mainly explored the types of blockchain (Siba and Prakash, 2016), its evolution (Swan, 2015), principles and potential advantages (Wang, 2017), as well as the recent consideration of its scope and obstacles (Hackius and Petersen, 2017). These studies focused on the development and management of blockchain technology positions but fail to understand the actual needs of shipping companies. To improve operational performance or reduce operating costs, shipping companies must first understand the principles, characteristics, types, benefits, opportunities, costs, risks, and application scope of blockchain; then consider the external opportunities and risks as well as internal benefits and costs generated by the introduction of blockchain.

III. THE METHODOLOGY AND EVALUATION FRAMEWORK

3.1 The Fuzzy Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) was proposed by Saaty in 1971 and was characterized by its use of pairwise comparisons to judge the relative importance of evaluation criteria (Ngai, 2003). By evaluating the relative importance ratio between the criteria, it seeks to obtain the relative weights of the evaluation factors by rating category levels with a hierarchical scale according to their priority. This process has been widely used in many fields, such as economics, political, social, and management sciences. However, the AHP cannot properly represent the subjective perceptions and judgments of survey respondents in evaluation criteria because it is difficult to reflect the problems faced in strategic analysis in a real environment (Lee, 2009).

To improve the inability of traditional AHP method on accurately reflecting and representing human thinking patterns in the real world (Remica and Sanjeet, 2013), Van Laarhoven and Pedryce (1983) combined Fuzzy Set Theory (FST) and fuzzy operations into the Fuzzy AHP to solve the problem of uncertainty and ambiguity in reality. In addition, this method can also effectively integrate the opinions of senior managers of shipping companies, thus making it possible to further explore the perceptions of shipping respondents regarding the issue. The calculation steps are as follows.

Step 1: Establish fuzzy paired comparison matrix

Assuming a fuzzy paired comparison matrix with $\tilde{A}_r$.

$$\tilde{A}_r = \begin{bmatrix} 1 & \tilde{a}_{12(U-R)} & \cdots & \tilde{a}_{1n(U-R)} \\ \tilde{a}_{21(U-R)} & 1 & \cdots & \tilde{a}_{2n(U-R)} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1(U-R)} & \tilde{a}_{n2(U-R)} & \cdots & 1 \end{bmatrix} \tag{1}$$

$$\tilde{a}_{ij} = \left[l_{ij}, m_{ij}, u_{ij}\right],\ \tilde{a}_{ij} \cdot \tilde{a}_{ij} \approx 1,\ \forall_{ij} = 1,2,\ldots,n$$

Where l_{ij} is the lower limit value, m_{ij} is the most promising value, and u_{ij} is the upper limit value.

Step 2: Consistency check of fuzzy matrix

The consistency of this paired comparison matrix needs to be judged to determine the ratio of the matrix and estimate whether the logical relationship of the sample collection is close to a random collection. Therefore, the consistency index (*C.I.*) and consistency ratio (*C.R.*) are employed to test matrix consistency.

$$C.I. = \frac{1}{n-1}(\lambda_{max} - n) \tag{2}$$

$$C.R. = \frac{C.I.}{C.R.} \tag{3}$$

where n is the number of criteria and λ_{max} is the maximum eigenvalue.

Saaty (1977) has suggested that when $C.R. \le 0.1$, the consistency of the evaluation matrix will be guaranteed. If $C.R. \le 0.1$, the degree of matrix consistency will be considered satisfactory.

Step 3: Calculate fuzzy weight

For calculating the fuzzy weight, the column vector geometric average method is used. In addition to acquiring the fuzzy weight of the fuzzy positive reciprocal matrix, normalization can be achieved (Buckley, 1985). The fuzzy weight value $\tilde{W}_i$ is calculated as follows:

$$\tilde{W}_i = \tilde{Z}_i \otimes \left(\tilde{Z}_1 \otimes \tilde{Z}_2 \otimes \ldots \otimes \tilde{Z}_N\right)^{-1} \tag{4}$$

$$\tilde{Z}_i = \left(\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{iN}\right)^{1/N},\ \forall_i = 1,2,\ldots,N \tag{5}$$

Where $\tilde{Z}_i$ is the geometric mean of triangular fuzzy numbers.

Step 4: Defuzzification

According to the center of area method proposed by Teng and Tzeng (1993) for defuzzification, the process for calculating the fuzzy weight value (DF_{ij}) is:

$$DF_{ij} = \frac{\left\lfloor \left(u_{ij} - l_{ij}\right) + (m_{ij} - l_{ij}) \right\rfloor}{3 + l_{ij}} \tag{6}$$

Step 5: Normalization

The process of normalized weight calculation (NW_i) is:

$$NW_i = \frac{DF_{ij}}{\sum DF_{ij}} \tag{7}$$

Step 6: Calculate hierarchical fuzzy weights

If, in aspect i, the fuzzy performance score of criteria j is $\tilde{a}_{ij}$, and the weight of j is $\tilde{\omega}_j$, the fuzzy weight value $\tilde{u}_i$ of i is obtained by this conversion:

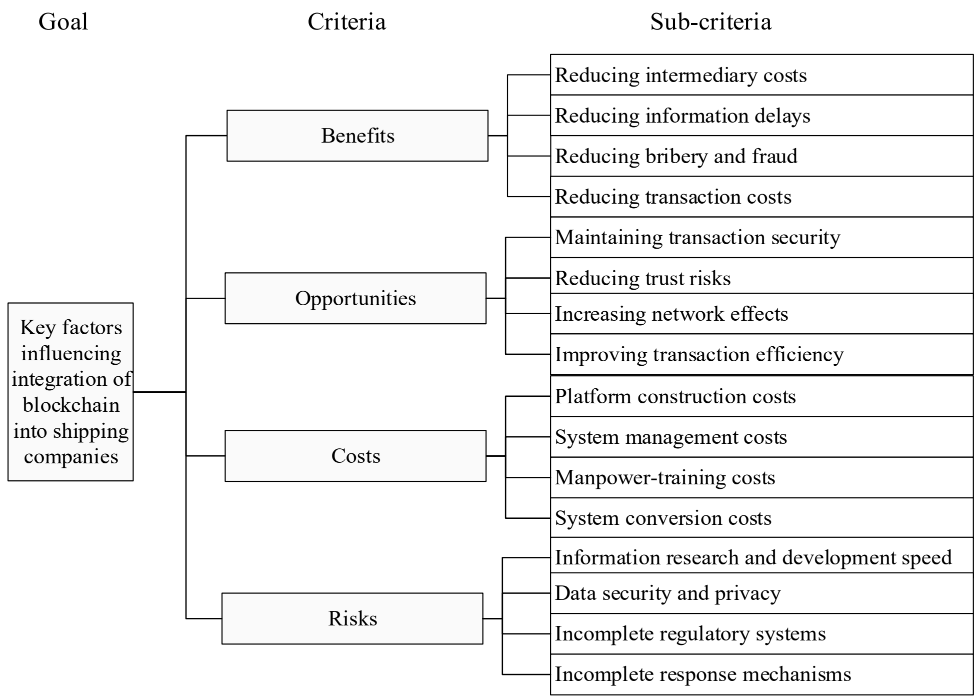

Fig. 1. Evaluation framework of key factors influencing integration of blockchain into shipping companies

$$\tilde{u}_i = \sum_{j=1}^{n} \tilde{\omega}_j \tilde{a}_{ij} \tag{8}$$

3.2 Evaluation Framework for Impact Criteria

Benefits, Opportunities, Costs, and Risks of the BOCR model could be combined with multi-criteria decision-making methods (Saaty, 1999). First, depending on the complexity of the decision, sub-objectives or sub-criteria can be developed to support decision-makers making better decisions. Besides solving positive and negative effects of the problem simultaneously, the BOCR model can incorporate expert opinions into the decision-making process and compare it with existing relevant models. The BOCR model is superior to other models because BOCR's benefits (B) and opportunities (O) could have a positive impact while costs (C) and risks (R) could have a negative impact on the company (Kang et al., 2011). When making decisions, managers always eager to maximize benefits and opportunities but minimize the costs and risks. Benefits and costs are respectively positive and negative criteria that the company actually faces while opportunities and risks are independently positive and negative criteria that the company potentially will face. Therefore, the BOCR model has been widely utilized in many fields, effectively providing an important reference for decision-makers.

In order to construct objective and complete criteria as well as a framework for evaluating the positive and negative impacts on introducing blockchain to shipping companies, this research first reviewed the relevant literature concerning the key factors influencing the integration of blockchain into shipping companies. Then, it combined the BOCR framework proposed by Saaty's (1999), and targeted the evaluation objectives, criteria, and guidelines for constructing a framework for evaluating the key influencing factors, as shown in Figure 1.

The study divided the evaluation criteria into Benefits (B), Opportunities (O), Costs (C), and Risks (R). In terms of evaluation sub-criteria, "benefits" included "reducing intermediary costs," "reducing information delays," "reducing bribery and fraud," and "reducing transaction costs". "Opportunities" contained "maintaining transaction security," "reducing trust risks," "increasing network effects," and "improving transaction efficiency." "Costs" were comprised of "platform construction costs," "system management costs," "manpower-training costs," and "system conversion costs." "Risks" involved "information research and development speed," "data security and privacy," "incomplete regulatory systems," and "incomplete response mechanisms."

IV. EMPIRICAL ANALYSIS

This section describes the analysis of effective questionnaire responses collected from professional managers of information and operation departments in shipping companies. Responses that they made according to their work experience and knowledge were analyzed by using Excel software to shed light on the importance of key factors influencing the integration of blockchain technology.

Table 1 Analysis of Importance of Key Factors Influencing Integration of Blockchain Technology into Shipping Companies

Evaluation Criteria	Weight (Sorted)	Evaluation Sub-criteria	Weight (Sorted)		Overall Weight (Sorted)	
Benefits (B)	0.3276 (1)	(B1) reducing intermediary costs	0.0754	(16)	0.0247	(16)
		(B2) reducing information delays	0.2633	(6)	0.0862	(4)
		(B3) reducing bribery and fraud	0.4467	(1)	0.1464	(1)
		(B4) reducing transaction costs	0.2146	(10)	0.0703	(5)
Opportunities (O)	0.2318 (3)	(O1) maintaining transaction security	0.1771	(14)	0.0411	(14)
		(O2) reducing trust risks	0.2407	(8)	0.0558	(9)
		(O3) increasing network effects	0.2059	(12)	0.0477	(11)
		(O4) improving transaction efficiency	0.3763	(2)	0.0872	(3)
Costs (C)	0.1712 (4)	(C1) platform construction costs	0.1594	(15)	0.0273	(15)
		(C2) system management costs	0.2648	(5)	0.0453	(12)
		(C3) manpower-training costs	0.2487	(7)	0.0426	(13)
		(C4) system conversion costs	0.3271	(4)	0.0560	(8)
Risks (R)	0.2694 (2)	(R1) information research and development speed	0.2032	(13)	0.0547	(10)
		(R2) data security and privacy	0.3696	(3)	0.0996	(2)
		(R3) incomplete regulatory systems	0.2147	(9)	0.0578	(6)
		(R4) incomplete response mechanisms	0.2125	(11)	0.0573	(7)

4.1 The Questionnaire and the Result

In view of the small number of respondents in the shipping industry with good understanding of the research subject, judgmental sampling was adopted. This sampling method is simple, inexpensive, and consistent with the purpose and special needs of the survey. Research questionnaires were sent out by e-mail to senior managers from the information and operation departments of shipping companies listed in Taiwan, including U-Ming Marine, China-Steel Express Corp., Wisdom Marine Lines Co. Ltd., Kuang Ming Shipping Corp., Sincere Navigation Corp., Shih Wei Navigation Co. Ltd., First Steamship Co. Ltd., Taiwan Navigation Co. Ltd., Evergreen Marine Corp., Yang Ming Marine Transport Corp., Wan Hai Lines Ltd., TS Lines Co. Ltd., and others. A total of 20 questionnaires were distributed, and 18 were returned. Among them, 16 were valid questionnaires, leading to an effective questionnaire response rate of 80%.

4.2 Analysis of Importance of Influencing Factors

Maersk lines and IBM have pioneered to build a shipping logistics blockchain in cooperation. Therefore, this research has invited the experts of Maersk lines and IBM that engaged in blockchain projects to conduct pre-tests and adjust the applicability of the evaluation sub-criteria in order to satisfy the completeness and applicability of the research questionnaires. When valid questionnaires were reviewed and evaluated, the *C.I.* value of the four criteria and 16 evaluation sub-criteria was 0.0078, and the *C.R.* value was 0.0087, indicating that these questionnaires met the consistency requirement. The analysis of the importance of key factors affecting introduction of blockchain technology in shipping companies in Taiwan is shown in Table 1.

As seen in Table 1, the four evaluation criteria, ranked in order of importance, are benefits (32.76%), risks (26.94%), opportunities (23.18%), and costs (17.12%). As far as the evaluation sub-criteria are concerned, the most important factors influencing introduction of blockchain technology in shipping companies, ranked in order of importance, are “reducing bribery fraud” (14.64%), followed by “data security and privacy” (9.96%), “increasing transaction security” (8.72%), “reducing information delays” (8.62%), “reducing transaction costs” (7.03%), “incomplete regulatory systems” (5.78%), “incomplete recovery mechanism” (5.73%), “system conversion costs” (5.60%), “reducing trust risks” (5.58%), and “speed of information research and development” (5.47%). The total weight of the above 10 sub-criteria is 77.13%.

4.3 Analysis of Importance of Influencing Factors

As well as national policies encourage and support the development of blockchain application industries, shipping companies can be assisted in integrating blockchain technology, and the transformation and upgrading of industries can be accelerated. Shipping companies can also be strengthened as they integrate blockchain technology, which is relevant to the key influencing factors related to benefits and opportunities in order to reduce information delays, bribery fraud, transaction costs, and trust risks. Enhance not only does the transaction efficiently improve, but also the service quality of the shipping industry to cope with the high competition in the international shipping market. On the other hand, excessive protection may reduce market competitiveness since shipping is a global industry. Therefore, the government should focus on the adoption of supervision and risk management. Other non-regulated items might allow shipping companies to have more room in operation and technology applications.

Through the integration of sound supervisory regulations and international asset protection, the negative impacts of key influencing factors on risk structures when shipping companies integrate blockchain technology, such as data security and privacy and an incomplete regulatory system, are effectively reduced. In terms of shipping company costs, government-related units can collaborate with the Asian Blockchain Alliance and the shipping industry to build a blockchain infrastructure jointly for shipping, logistics, trade, and finance, where the operators of transportation supply chain only need to apply to join. Without the demand of building each other's system, using these collaborative cloud services could be conductive to integrate blockchain technology into shipping companies through effectively reducing platform construction and system operation and management costs. If the shipping company builds its own hybrid or private chain, there is no need to convert the original system, which can efficiently eliminate human training costs and system conversion costs. In view of the above analysis, it is recommended that shipping companies should integrate public chains and avoid self-built private chains to effectively realize the benefits and opportunities, while reducing costs and risks.

Although blockchain technology provides great business opportunities and potential application value, it would affect the existing social and economic structure and regulatory norms. Regarding Taiwan's blockchain technology management and policy, blockchain technology is characterized by decentralization, meaning that it avoids public sector control. On May 22, 2018, the Taiwan Crypto Blockchain Self-Regulatory Organization (TCBSRO) was established on the principles of legal compliance, confidentiality, integrity, good management, open transparency, and fair competition, requiring blockchain operators to exercise self-discipline and communicate with the government. In addition, relevant government units standardize blockchain application industry positioning, taxation, and penalties, and establish self-regulatory organization implementation rules to create a safe and open industry environment for Taiwan's blockchain application industry. Furthermore, in order to strengthen the blockchain technology partnership between Taiwan and China, the Cross-strait Blockchain Alliance (CBA) was established in Taiwan on July 1, 2018 to promote the development of blockchain technology, foster blockchain academic exchanges, enhance industry cooperation, assist new industries, and set up investment funds to advance development of blockchain industries besides integration in the financial sector.

V. CONCLUDING REMARKS

1. This research explored the importance of key factors influencing integration of blockchain technology into shipping companies in Taiwan to shed light on the benefits and opportunities, and to increase willingness of integration for strengthening competitive advantage of these corporations in global operations. The importance of the key factors was analyzed structured on the benefits, opportunities, costs, and risks (BOCR) model. Analysis results revealed that the most important evaluation criteria were "benefits," followed in order by "risks," "opportunities," and "costs."
2. Concerning the evaluation sub-criteria, the most important factor affecting application of blockchain technology in shipping companies was "reducing bribery fraud" (14.64%), followed by "data security and privacy" (9.96%), "improved transaction efficiency" (8.72%), "reduced information delays" (8.62%), "reduced transaction costs" (7.03%), "incomplete regulatory systems" (5.78%), "incomplete response mechanisms" (5.73%), "system conversion costs" (5.60%), "reduced trust risk" (5.58%), and "information research and development speed" (5.47%).
3. Owing to the constantly updating and expanding application of blockchain technology, shipping companies in Taiwan face a rapidly changing information environment, making it indeed necessary to develop a plan for the integration of blockchain technology. In practice, bulk-shipping services involve fewer parties than container shipping services, and there may be differences in business operations. This research recommends that different types of ships used by bulk shipping services, short-sea and deep-sea container shipping services, domestic and foreign, company scale, and listing should be distinguished to analyze the differences in key factors affecting integration of blockchain technology into different types of shipping companies.

ACKNOWLEDGMENTS

The authors thank the Ministry of Science and Technology, Taiwan, R.O.C. for providing financial supports (MOST107-2410-H-451-001).

REFERENCES

Buckley, J. J. (1985). Fuzzy hierarchical analysis. Fuzzy Sets and Systems 17, 233-247.

Burnham, T. A., J.K. Frels and V. Mahajan (2003). Consumer switching costs: a typology, antecedents, and consequences. Journal of the Academy of Marketing Science 31(2), 109-126.

Chang, C. C. and C. P. Li (2001). A survey and analysis on the quality, training, recruitment and application of informational human resources. Journal of Technological and Vocational Education 4, 1-20.

Chen, H. H., S. C. Chen and J.Y. Lin (2011). Examining the effect of technology readiness and switching costs to operating system switching intention. Electronic Commerce Studies 9(2), 133-156.

Davidson, S., P. De Filippi and J. Potts (2016), Economics of Blockchain, https://hal.archives-ouvertes.fr/hal-01382002/document, Retrieved on Nov. 14, 2019.

Ding, J. F, J.F. Kuo and W.H. Tai (2019). Using fuzzy AHP method to evaluate key competency and capabilities of selecting middle management for global shipping logistics service providers. Scientific Journal of Maritime Research 33(1), 3-10.

Duh, R.R., K. Jamal and S. Sunder (2002). Control and assurance in e-commerce: privacy, integrity, and security at eBay. Taiwan Accounting Review 3(1), 1-27.

Finextra (2017), Making Blockchain Ready for Business - the Findings of a Roundtable Discussion from Finextra and IBM, London: Finextra.

Gao, T., S. Na,, X. Dang and Y Zhang (2018). Study of the competitiveness of quanzhou port on the belt and road in china based on a Fuzzy-AHP and ELECTRE III Model. Sustainability 10(4).

Hackius, N. and M. Petersen (2017). Blockchain in logistics and supply chain: Trick or treat?. Proceedings of the Hamburg International Conference of Logistics, epublic, 3-18.

Kang, H.Y., M.C. Hung, W.L. Pearn, A.H.I. Lee and M.S. Kang (2011). An integrated multi-criteria decision making model for evaluating wind farm performance. Energies 4(11), 2002-2026.

Kshetri, N. (2017), Blockchain's Roles in Strengthening Cybersecurity and Protecting Privacy, Telecommunications Policy, https://doi.org/10.1016/j.telpol, Retrieved on Sept. 3, 2019.

Kuo, R.J. (2016). An analysis of legal issues in the application of blockchain technology and intelligent contracts. Science and Technology Law Review 28(12), 32-42.

Lee, A.H.I. (2009). A fuzzy supplier selection model with the consideration of benefits, opportunities, costs and risks. Expert Systems with Applications 36(2), 2879-2893.

Lin, T.Y., C.C. Chung and T.C. Ho (2019). An evaluation of the key influencing factors for tramp shipping corporations selecting ship management companies. Journal of Marine Science and Technology 27(2), 133-143.

Lo, Y.S. (2017). The status and challenges of decentralized ledgers and blockchain application. Economic Outlook Bimonthly 173, 79-84.

Lootsma, Y. (2017), Blockchain as the newest regtech application - the opportunity to reduce the burden of KYC for financial institutions. Banking and Financial Services Policy Report 36(8), 16-21.

Ngai, E.W.T. (2003). Selection of Websites for Online Advertising Using the AHP. Information and Management, 40(4), 233-242.

Remica, A. and S. Sanjeet (2013). AHP and extent fuzzy AHP approach for prioritization of performance measurement attributes. International Journal of Social, Behavioral, Educational, Economic and Management Engineering 7(1), 43-48.

Saaty, T. L. (1977). A scaling method for priorities in hierarchical structural. Journal of Mathematical Psychology 15(3), 234-281.

Saaty, T. L. (1999). Fundamentals of the analytic network process. International Symposium on the Analytic Hierarchy Process (ISAHP), Aug. 12-14, Kobe, Japan, 48-63.

Shrier, D., J. Larossi, D. Sharma and A. Pentland (2016). Blockchain and transactions, markets and marketplaces, https://www.getsmarter.Com/career-advice/wp-content/ploads/2017/07/mit_blockchain_transactions_report.pdf, Retrieved on Nov. 21, 2019.

Siba, T. K. and A. Prakash (2016). Block-chain: an evolving technology. Global Journal of Enterprise Information System 8(4), 29-35.

Soong, H.W. and H.G. Chen (2002). Policy management in the era of globalization and www. Journal of Information Management 8(2), 153-173.

Swan, M. (2015), Blockchain: Blueprint for a New Economy, California, O'Reilly Media, Inc.

Tapscott, D. and A. Tapscott (2016), Blockchain Revolution, 1st Ed., New York: Penguin Random House.

Teng, J.Y. and G. H. Tzeng (1993). Transportation investment project selection with fuzzy multi-objectives. Transportation Planning and Technology 17(2), 91-112.

Van Laarhoven, P. J. M. and W. Pedryce (1983). A fuzzy extension of Saaty's priority theory. Fuzzy Sets and Systems 11(3), 229-241.

Wan, Y.Y., Y. Tseng and M.C. Chang (2017). Development, application, and management of blockchain technology. Internal Auditors 99, 4-8.

Wang, C.T. (2017). Blockchain, Taipei, Chuang Jian Culture.

White, L. (2015). The market for cryptocurrencies. Cato Journal 35(2), 383-402.

Wiles, N. (2015). The radical potential of blockchain technology. https://www.youtube.com/watch?v=JMT0xwmFKIY, Retrieved on Dec. 14, 2019.

Zhao, J.L., S. Fan and J. Yan (2016). Overview of business innovations and research opportunities in blockchain and introduction to the special issue. Financial Innovation 2(1), 1-7.