A MODEL FOR IMPLEMENTING BLOCKCHAIN TECHNOLOGY IN THE ORGANIC RICE SUPPLY CHAIN IN NORTHEASTERN THAILAND

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Abstract - There is a lack of interoperability, transparency, and traceability in the organic rice supply chain in Northeastern Thailand. Prior studies have tried to solve the problems of organic rice supply chain management; however, the results are not satisfying, and the problems remain, suggesting a need for improvement and increased efficiency. Corresponding to the Thai government's policy for encouraging 'smart farmers', the adoption of blockchain technology is hoped to enhance the management of the organic rice supply chain since it provides a distributed database, traceability, and transparency. Thai farmers may gain advantages after implementing blockchain technology. Therefore, this study is to investigate howblockchaintechnology can overcomeinconsistencies and shortages in the organic rice supply chain. The data collection was based on a literature review. The results of this study developed and proposed amodel for implementing blockchain technology in the organic rice supply chain in Northeastern Thailand. The model usesblockchain features as a central component in managing and controlling the entire supply chain of organic rice farming.

Keywords - Blockchain, Organic rice supply chain, Smart farm, Thailand

I. INTRODUCTION

Nowadays,the trend of a 'back to nature' lifestyle has emergedin which people are more aware of the adverse impact of agrochemical input (Ashari et al., 2016). Peopleare becoming more concernedwithfood safetyand care more about their health(Jierwiriyapant et al., 2012;Kongsom & Panyakul, 2016;Pakdeenarong & Hengsadeekul, 2020). They require natural food with low levels of chemical content (e.g. fertilizers and pesticides) (Kongsom & Panyakul, 2016). As a result, organic rice is introduced as being a betteralternative choiceof organic source of food.

According to National Bureau of Agricultural Commodity and Food Standards (2010: 1), organic rice refers to the produce of rice derived from the organic rice productionsystem. This is a system of rice production management that enhances the ecosystem and sustains biodiversity and biological cycles. The organic rice productionsystememphasizes the useof natural materials by opposing the use of synthetic raw materials, transgenic plants, animals,microorganisms or raw materials derived from genetic modification. It also covers product management, which carefully emphasizesat every processing step the maintenanceoforganic integrity and the quality of organic rice products. Therefore, people are assured that organic rice is natural and resistant to chemical enhancement.
Customers want assurance that the rice that they ordered is organic, and this issue remains an open question since there is evidence that the organic ricesupply chain in Thailand is substantially inefficiently managed(Jaroenwanit, 2011;Pongsrihadulchai, 2018; Kuptapan,2007). It lacks interoperability, transparency, reliability, and traceability of product information in the supply chain. When the supply chain is inefficient, it impacts all sectors in the chain, from producers to customers(Tripoli & Schmidhuber, 2018). Therefore, there is a need for increased efficiency in the management of the organic rice supply chain.

In 2016, the Thai government issued Thailand 4.0. The objectives of Thailand 4.0 are the use of technology and innovation to create added value for agricultural products(Ruaykijakarn et al., 2018). Corresponding to this policy, Thai farmers were incentivized by the government to learn how to adapt by changing traditional agricultural ways of farming to technology-led cultivation (Jones& Pimdee,2017: 15). A a result, Thai farmers are shifting to become 'smart farmers' by using technology (e.g., drones, mobile applications, the internet of things, robotics, artificial intelligence, blockchain, etc.) in their plantations. This allow them to produce cheaply, produce higher quality, and sell products on the market for better prices. The government expects that technology will facilitate the agricultural production and develop rural economics, so it may happen that the widespread use of technology may help eliminate weaknesses and enhance the sustainability of the organic rice supply chain in Thailand.

Blockchain is a potential technology that enables the enhancement of the agricultural chain. Blockchain is

a distributed database of records or shared public/private ledgers of all digital events that have been executed and shared among blockchain participating agents(Saberi et al., 2019: 2). The implementation of blockchain is intended to provide a digital database that records, tracks, monitors and transacts physical and digital assets (Tripoli & Schmidhuber, 2018). Participants in the blockchain can track every step of production in the supply chain from agriculture inputs (e.g., fertilizers, soil, water, etc.) used on the farm to the distribution channels,retailers and even consumer in real time. Particularly, as blockchain is a distributed database, participants cannot change the information shared in the blockchain. Moreover, a distributed blockchain database allows traders all around the world to access the information in the supply chain by using a private or public password. Therefore, blockchain provides an opportunity to overcome the shortages of the traditional supply chain management, such as interoperability, transparency, traceability, and security.

1.1 Problem

It is eident from statiatics and literature that the overall supply chain management of organic rice production is faced with chalenges. Despite efforts to improve management in the organic rice supply chain in Thailand, issues still persist regarding operational efficiency, interoperability, transparency, and traceability. Previous studies have shown limited success in addressing these challenges, indicating a gap in understanding and implementation of an effective suppply chain management. Given the Thai government's push for "smart farming" initiatives, as part of the Thailand's agriculture development plan since 2011 (Sisang, et al., 2020), there is growing interest in leveraging blockchain technology to enhance supply chain management. However, there remains a lack of comprehensive research into how blockchain can effectively address inconsistencies and shortages in organic rice farming supply chain.

Additionaly, the ability of blockchain technology to enhance organic rice supply chain in Thailand remains a subject of debate and uncertainty.While this technology has huge potential of promising features, there is still uncertainities regarding the most suitable clocjkchain model that could effectively address the inconsistencies and complexities of the organic rice supply chain in Northeastern Thailand. Identifying the most appropriate blockchain technology model tailored to the unique characteristics and challenges of the organic rice supply chain is crucial for its successful implementation and effectiveness.

Further, adoption of such high new and end-technology may pose a challenge to Thai farmers. Adoption rate may be hindered by various aspects including technological complexity, limited access to resources and training, and concerns about cost-effectiveness. Therefore, a suitable blockchain model should consider these aspects, to realize the full benefits of improving organic rice production and adding value to products along the supply chain.As well, based on our knowledge, research in this area is underdeveloped or only just starting. This knowledge gap underscores the need for further investigation into the practical implementation of blockchain technology to enhance operational efficiency, transparency, traceability, and overall efficiency in the organic rice supply chain.Therefore, the objective of this research is to develop and propose a tailored model that can be implemented to overcome these challenges and improve the organic rice supply chain management in Northeastern Thailand.

1.2 Objectives of the Study

The study is geared towards adressing the following objectives:

- Identify and evaluate existing blockchain technology capabilities applicable to the organic rice supply chain in Northeastern Thailand.
- To develop and propose a tailored model that can be implemented to overcome these challenges and improve the organic rice supply chain management in Northeastern Thailand.
- To investigate the benefitsfor the adoption of proposed blockchain technology model among Thai farmers.

1.3 Process and Importance

The study and the development of the proposed model will be grounded on a thorough review of existing literaure and secondary data on Thailand agricutural sector. Thailand holds a prominent position in the global rice market, ranking sixth in terms of production and second in rice exports (Pongsrihadulchai, 2018). Despite its significant role in the industry, challenges persist within the country‘s organic rice supply chain, particularly in the northeastern region. By synthesizing the information and findingsof previous literature and research, and statistics from analyzing the secondary data, the study deveoped a comprehensive model that could be implemented to address the chalenges and inefficiencies in organic rice farming in Thailand, under a case study of Northeastern region.

The study will make significant contributions to the agriculture-food supply chain. That is, we provide a model to demonstrate how blockchain technology can be implemented to enhance the organic rice supply chain management in Thailand.The proposed model would help improved supply chain efficiencies, through streamlined processses, reduced inefficiencies, smoother operations and reduced costs. Additionally, the study would lead to empowered farmers gain greater visibility and control over their

produce within the supply chain. The blockchain enabled technlogy could enble them access real-time information on pricing, market demand, and production standards, empowering them to make informed decisions and negotiate fair prices for their orrganic rice products.

The remainder of the paper is organized as follows. The next section includes a literature review. The third section proposed blockchain model. The final section provides conclusions.

II. LITERATURE REVIEW

2.1 The Important Role of Rice in Thailand

Rice is a staple food for the Thai people and is the most widespread crop in Thai agriculture. It has shaped the cultures, society, nutrition, and economies of the Thai nation(Gnanamanickam,2009). Rice production has long played an important role in Thailand's socio-economic development, making the country the world's largest rice exporter in the last three decades(Titapiwatanakun, 2012). It contributes around 15% of agricultural gross domestic product (GDP); is the first rank among all agricultural products; and is ranked second after rubber in the export value of agricultural products (Titapiwatanakun, 2012).

There are four main reasons why rice contributes so prominently to the economy of the Thai nation. Firstly, Thailand is located in the temperate zone where it is suitable to grow rice. Consequently, Thai farmers can grow the rice in two cropping seasons, namely the major crop and the second crop (Rice Department of the Ministry of Agriculture and Cooperatives, 2012;Titapiwatanakun, 2012). The major crop is grown from May to October and the second crop is grown from mid-June until February. Secondly, Thailandproduces three types of rice, including fragrant, non-fragrant, and glutinous, with rice varieties included in each type, so Thailand can export rice in diversified markets (Rice Department of the Ministry of Agriculture and Cooperatives, 2012; Titapiwatanakun, 2012). Thirdly, Thailand has been producing comparatively high-quality rice such as Jasmine rice or Hom Mali rice (Titapiwatanakun, 2012). Jasmine and Hom Mali rice are classified as fragrant rice[1]. It is long-grain, silky smooth and pure white, with a tender texture when cooked and a distinct fragrance, so it has become a popular type of rice for people around the world. In 2009, the Office of Agriculture Economics (OAE) reported that Thailand exported 8.6 million tons of rice, in which the largest proportion of the export is Jasmine rice with 31%. Lastly, it is supported by the Thai government, which encourages Thai farmers to grow rice, and provides financial support for developing rice production (Rice Department of the Ministry of Agriculture and Cooperatives, 2012).

Moreover, the Thai government also promotes sustainable agriculture and organic farming. According to the 7th National Economic and Social Development Plan (1997-2001), the government planned to have organic agriculture as the alternative strategy of agriculture leading to sustainable development(Win,2017). In 2012, the National Organic Agriculture Committee was established. It is responsible to set up policies and strategies for Thailand's organic agriculture and to integrate all related plans and measures. Recently, the National Organic Agriculture Committee implemented strategies for developing Thailand's organic agriculture industry to become a focal-point country in the production trade as well as the consumption of organic agriculture products (Win,2017: 2; The Government Public Relations Department, 2014). The government promoted organic agricultural products for both international export and domestic consumption.

2.2 Organic Rice Supply Chain in Thailand

The organic rice supply chain follows several stages, including material inbound, operation, manufacturing, distribution and marketing, and customers. The first stage of the chain is the material inbound. Farmland holders obtained the organic rice seeds from two sources: the community enterprise (a group of organic rice farmers) and the rice department. Then, organic rice seeds are distributed to farmland holders who are a member of the community enterprise and are interested in organic rice production. Next, the second stage is the operation. After receiving the organic rice seeds, the farmers will cultivate the organic rice. In this process, there is an assessment to ensure that the organic rice production is followed by the requirements of organic rice agriculture. This assessment includes three stages. First is the measurement of soil fertility. This process is to ensure that the quality of soil (i.e. soil nutrition) is appropriate for rice production. Second is a preventive measure, that is, a measure against contamination from adjacent farms orfrom polluted sources, such as water and air. Such measures are, for example, dike or cultivation of the buffer zone. If there is a risk of contamination, soil and water samples are taken for analysis (National Bureau of Agricultural Commodity and Food Standards, 2010: 2). Lastly is the estimation of the quantity of paddy in each farmland: how much paddy can each farmland produce. Next is the third stage of the chain: manufacturing. Farmers will bring the organic paddy to the mill of the community enterprise for husking, cleaning, and polishing. However, it can be the case

[1]Fragrant rice (e.g., Kao Horm Doc Mali 105, Suphan Buri Khao's Jow Hawn, Klong Luang 1, and Pathumthani 1). Non-fragrant white rice (many varieties). Glutinous rice (e.g., Niew Ubon, Niaw San-pah-tawng)(Titapiwatanakun, 2012:4).

that farmers need to spend money, and so they will instead sell the organic paddy to agents or retailers. Next, the fourth stage of the chain is distribution and marketing. The rice grain obtained from the milling will be sent to the community enterprise for packing, promoting and selling. Finally, the last stage of the chain is customers. After packing the organic rice, the community enterprise will directly distribute the organic rice products to the customers and retailers relying on their orders. Moreover, customers are also able to receive organic rice products from other agents and retailers. The organic rice supply chain in Thailand is as follows:

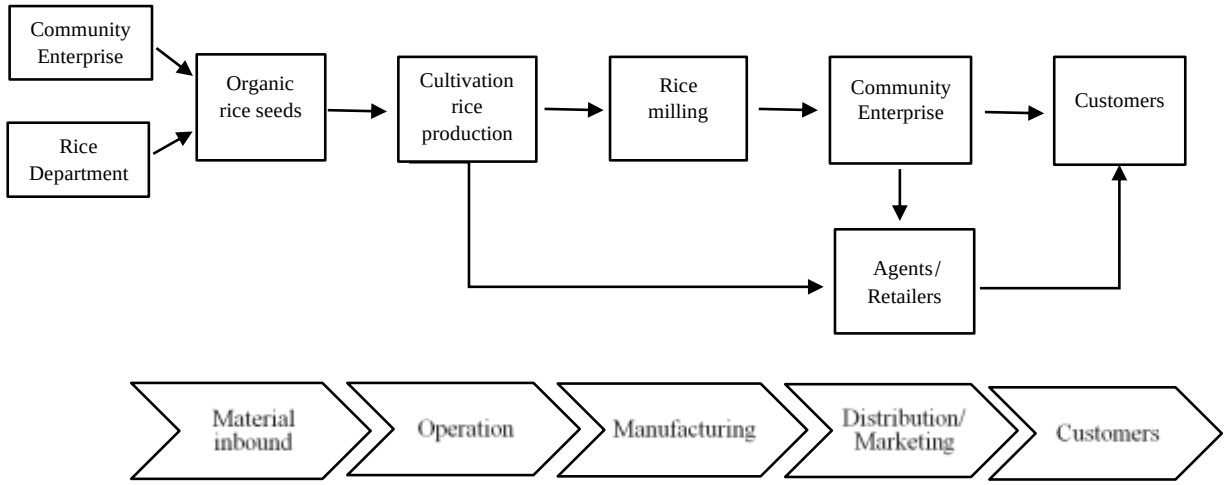


Figure 1. **Organic rice supply chain**

2.3 The Inefficiency of Current Organic Rice Supply Chain Management

Prior studies reveal that the organic rice supply chain in Thailand suffers from traceability and transparency (Pakdeenarong& Hengsadeekul, 2020; Pongsrihadulchai, 2018;Jaroenwanit, 2011; Kuptapan,2007). The farmers, traders/retailers, and customers face the problem of poor traceability of organic rice in the supply chain. They are unable to track the rice products along the supply chain. There are also problems with the timing of supply, with a lot of unpredictability as to when the product will arrive at each destination in the supply chain. All of these compounds to create concerns over transparency, especially when there are weaknesses in the consistency and availability of data(Tripoli & Schmidhuber, 2018). People along the supply chain cannot trace the products in each stage. Therefore, there is a concern about product transparency and product quality. It might be the case that there is fraud rice during transportation. So, the rice at the beginning chain might not be the same as that arriving at the last destination of the chain.

2.4Blockchain Technology as a Solution

Blockchain was first introduced in 2008 as the cryptocurrency system for Bitcoin(Nakamoto,2008). Blockchain is a digital database that uses cryptocurrency to link and secure transactions or data entries, and disintermediates data processing and data storage with a peer-to-peer distributed network of computers that is used to validateand store transaction history and information(Tripoli & Schmidhuber, 2018:3). Therefore, blockchain functions to perform decentralized instructions to ensure trust and value transfer between users.

2.4.1 Disintermediation Capabilities

The mechanism of blockchain includes three main features. First, blockchain disintermediates the processing and storage of data entries(Tripoli & Schmidhuber, 2018). Formerly, institutions ensure trust relying on the intermediation where the information (e.g. transaction, contract) is stored in a centralized ledger, and it is a risk that hackers may intend to modify or steal data(Casado-Vara et al., 2018). Moreover, since it is the centralized database, the execution of the transactions will be costly and time-consuming. In addition, the centralized database also limits data accession and control for the users. On the other hand, blockchain is a decentralized distributed ledger. When a transaction happens, the information will be sent instantly to the participants' computers on the network which ensures up-to-date information. The mechanism of a decentralized distributed ledger is built on the consensus algorithm that all participants agree on for data entry and the sharing of information, therefore this feature can remove intermediation. Moreover, it also offers greater cost efficiency, better transaction time and the reduction of transaction fees(Tripoli & Schmidhuber, 2018).

2.4.2 Immutability & Security for Data Entries

Second, blockchain uses cryptography to ensure immutability and security for data entries (Tripoli & Schmidhuber, 2018). Each time that data enters the database, or block, the data will be recorded with a timestamp and a cryptographic fingerprint of record

that is called 'hash'(Nakamoto,2008). Hash is designed to link data in each block and store data securely across each block in the chain whereby the users cannot modify it without notably affecting all of the entries in the ledger (Casino et al., 2019). This makes fraudulent activity in the distributed ledger immediately visible to all other users in the chain (Tripoli & Schmidhuber, 2018).

2.4.3 Traceability & Transparency

Third, blockchain provides traceability and transparency. The immutability of records and the disintermediation of data storage, through a shared ledger, make every transaction or record in a distributed ledger traceable and transparent (Tripoli & Schmidhuber, 2018: 4). Since blockchain is a distributed ledger, all users can assess the full transaction history registered in the database. They will see the information movement in which they know that each piece of information is shared and with whom. Moreover, the information stored on the ledger in blockchain is protected by encryption and managed with private and public keys, so the users can control and protect who can access their information on the blockchain and when. For example, when the producers would like to share the data with the banks, they can use the bank's public key to encrypt before sending the data. Then, the bank will decrypt the data from the producers by using their private key, so the bank can verify that the data is exactly that which belongs to the producers by referring to the producer's public key.

III. PROPOSED BLOCKCHAIN MODEL

Based on the supply chain's shortages, we propose the model implementing blockchain technology to the organic rice supply chain (see Figure 2) in which blockchain features as a central component managing and controlling the entire supply chain.

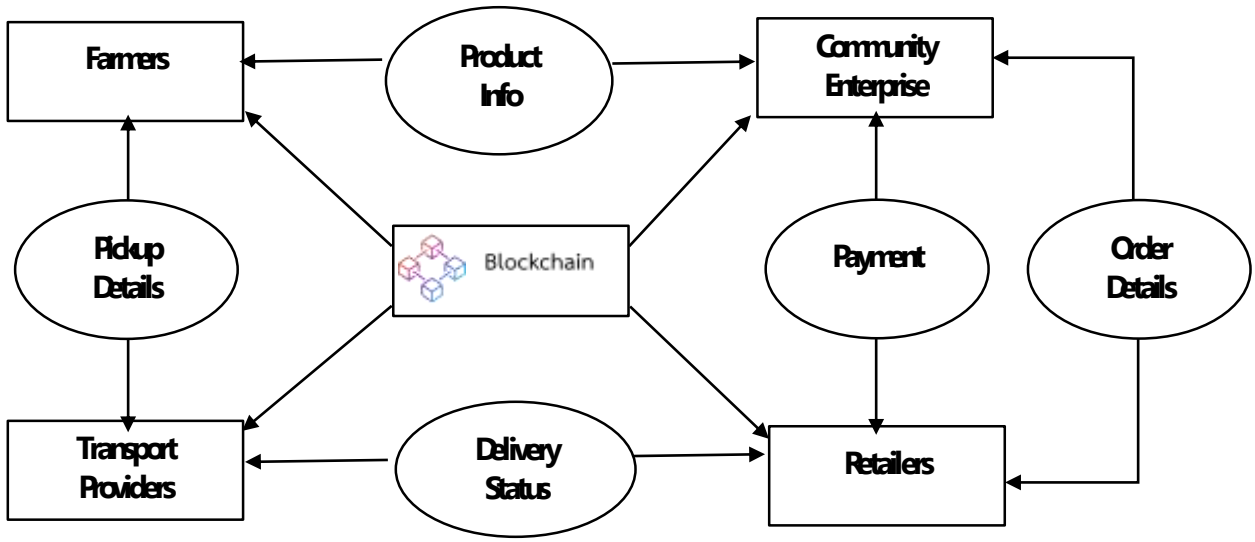
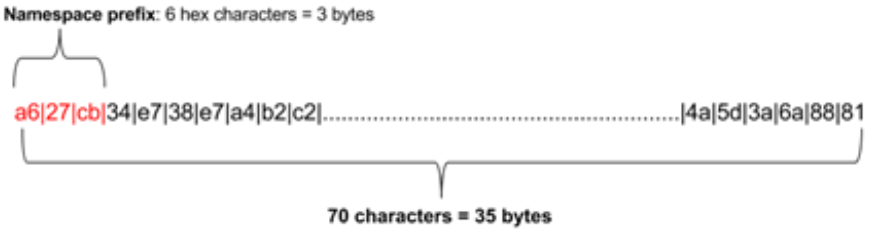


Figure 2. Organic rice supply chain via Blockchain

Regarding the working of the proposed model, firstly, the customers/retailers will order the organic rice products with the community enterprise. A smart contact will be generated, and the transaction ID (order details) will be added in the central server (blockchain). Then, the community enterprise will send the order details to the farmers.After the farmers receive the order details, they provide organic rice products based on the order details in the transaction ID. When they finish preparing the order, the farmers will add the upstream data (i.e., products, pedigree, quality inspections, etc.) to a central server using farmer's address/public key as follow.



Next, the transport provider will collect organic rice products from the farmers and deliver them to the customers. The transport provider will use address/public key to add the information of transportation (e.g., customer name,

customer'saddress, the number of products, weight, transportation's status, etc.) in the central server. Alternatively, the farmers can send organic rice products to the community enterprise. Then, the community enterprise will deliver the products to the customers/retailers. The community enterprise will also add the same information as the transport provider in the central server. Lastly, the customers/retailers can access a central server by using their address/public key. They can track the status of the product's delivery in the blockchain relying on the transaction ID. Meanwhile, all parties in the supply chain can trace the products' progress in the blockchain network by tracking the transaction ID. They can check every stage of the products' status.

3.1 Benefits of the Proposed Model

- Enhanced Transparency:using blockchain as a central component in the overall organic rice farming supply chain ensures secure data storage in a decentralized ledge. As a result, all stakeholders – customers, retailers, community enterprises, and farmers – have access to immutable and accurate information.
- Improved Traceability:The technology enables complete tracking of the organic rice products in every stage of the supply chain. This is achieved using a transaction ID which bears details about the products such as source, production methods, and quality inspections, shipping methods etc. It is thus easy to solve any issue that may arise, as well as guaranteed accountability.
- Efficiency in Supply Chain Management:this model would streamline the complete process, from farmers activities, through ordering to fulfillment process. Customers and retailers can place orders directly with community enterprises, which are then seamlessly communicated to farmers.This reduces the likelihood of errors, delays, and misunderstandings, leading to smoother operations and improved customer satisfaction.
- Empowered Farmers:farmers are offered greater visibility and control over their products throughout the supply chain. Farmers can easily access and update upstream data, such as product details, pedigree information, and quality inspections, using their unique address/public key.

IV. CONCLUSIONS

Since organic rice supply chain management in Thailand lacks interoperability, traceability, and transparency; this study investigates how blockchain technology can overcome these shortcomings and enhance the effectiveness and efficiency of the organic rice supply chain. Based on the literature review, we show that the advantages of the blockchain as a distributed database. It is able to carry transaction details and product attributes across the entire organic rice supply chain. All organic rice supply chain parties can track and trace product information in any specific time or stage of the food chain (from production to end-user) in real-time. Therefore, blockchain enables quality transactions and enhances traceability. Consequently, blockchain has high potential as a mechanism to overcome the lack of traceability and transparency in Thailand's organic rice supply chain.

However, to successfully implement blockchain, researchers need to identify how to introduce new technology like blockchain to traditional users, such as Thai farmers. Therefore, before implementing blockchain technology, researchers need to create awareness and information on the benefits of using blockchain, training on how to use and implement the blockchain technology in their processes, as well as support service after installation to all relevant parties in the organic supply chain. Moreover, the researchers need to examine demographics of technology adoption. For instance, young farmers may be more proactive in adopting blockchain technology compared to old farmers. Thus, they can implement new technology more quickly than old farmers.

This study has limitations from which further research could be developed. Firstly, this study provides a model for implementing blockchain technology in Northeastern Thailand's organic rice supply chain.A further study may investigate how well blockchain has been implemented and to what extent it is able to enhance the efficiency of the organic rice supply chain. Secondly, our proposed model is only incorporating four parties, further study may broaden the model by increasing the number of parties, such as a bank or exporters.

ACKNOWLEDGEMENT

We thank the Faculty of Business Administration and Accountancy, Khonkaen University, Thailand, for research funding.

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