

Proceedings

Impact of Blockchain Adoption for Safe Food Supply Chain Management through System Dynamics Approach from Management Perspectives in Thailand [†]

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Abstract: Today's food supply chain is incredibly complex and imposes enormous challenges across the Globe. Products are transported through multimodal transportation internationally, comprising of combination of ship, rail, truck and flight modes etc. The supply chain under multistage network poses more quality related issues. Hence, blockchain technology helps to enhance food safety and quality in the logistics process. This, when coupled with the existing traceability system can create more agile value chain and closer customer relationship across regions. Though, Thailand is a leading food exporter, it lacks in implementation of blockchain technology. The objective of this study is to analyse the impact of blockchain technology adoption for safe food supply chain management through System Dynamics (SD) approach from management perspectives in Thailand. The preliminary survey and discussion were carried out with the participants from food expert firms, and causal loop diagrams and stock and flow diagrams were developed and validated. The trade-off, challenges and opportunities of applying block chain technology on the global food value supply chain has been discussed throughout the system dynamics model. The major contribution of this work is in providing insight into some of the main dimensions of block chain technology and its implications for global food value chain performance improvements.

Keywords: blockchain; transportation; logistics; food safety; system dynamics; supply chain management

1. Introduction

We become what we eat. Food safety has become the focus of a society that is increasingly concerned about what they consume and where the products come from. Many people no longer comply with the food products and their information offered at the supermarkets, but also seek the security that what they buy comes from reliable sources and that there is no opacity or tampering in the product information. Since this has become a main global issue, building a food supply chain traceability system is becoming more and more urgent. Thailand is one of the leading agricultural producers in the world. With recent dynamic growth of agricultural industries and export of food, food safety in supply chains has become an important topic in Thailand [1]. Nowadays supply chains

are becoming more and more complex in structure, difficult in terms of task, and diverse in terms of stakeholders, and many organizations do not have an integrated view of the entire supply chain. Many large organizations have built their own identities and systems to maintain a global coverage of operations and have power to instruct their suppliers. Otherwise, they have to rely on centralized regulatory bodies or intermediaries. This low transparency causes many problems and difficulties in the supply chain mechanism in terms of food safety, security, traceability, authentication, and verification system [2]. A potential solution to alleviate the above issues and concerns is usage of blockchain technology, which is a new digital technological approach underpinned by the Industry 4.0 to ensuring data integrity and preventing tampering and any single point failure [3]. Blockchain is being applied in many fields such as digital currency, digital economy, operations and supply chains [4]. Blockchain can provide an immutable ledgers solution for several distributed participants in the chain by distributed software architecture and advanced computing technologies [2]. The main features of blockchain are that it is distributed, verified, and immutable [5]. The essence of Blockchain is a technical scheme of reliable database, which is collectively maintained by the way of decentralized and trestles method. This technical scheme could create blocks through any number of the nodes in the system by using cryptography. It is just like what the name says: a chain of blocks. Each block contains the data of all transactions in the system within a period of time, and it could create digital fingerprinting which can be used to verify the validity of the information and connect with the next block [6]. The blocks are linked to each other in a linear, chronological order with every block containing a hash of the previous block [7]. However, Blockchain is still an immature technology in many aspects, and it does not transform critical supply chain activities. Therefore, there is a wide gap between Blockchain potential and supply chain realization. Furthermore, many companies still have little knowledge about Blockchain, and there are still not many ready-to-use applications of blockchain in the supply chain domain [8]. Because of that, the purpose of this paper is to clarify the actual impact of blockchain adoption for safe food supply chain management in order to understand the behaviour of the system and the feedbacks that affect its dynamic thought system dynamics model approach.

2. Literature Review

Bosona and Gebresenbet [9] identified and discussed the definition, driving forces, benefits, barriers, improvements and performances of Food Traceability Systems (FTS) in order to conduct a literature review on food traceability issues. The current state of agro-food industries in East Asian countries and the application of traceability systems such as RFID in Thailand was review [10]. In the recent years, many authors have studied the possibilities of implementing Blockchain technology in many industries with the perspective of supply chain management due to its immaturity and lack of knowledge. Alfred Taudes and Tian [7] built a food supply chain traceability system for real-time food tracing based on Hazard Analysis and Critical Control Points (HACCP), Blockchain and Internet of Things. They also discussed the future challenges to adopt blockchain technology in food supply chain traceability systems. Helo and Hao [2] presented a classification of the possible applications of blockchain of supply chain management and demonstrated the technical architecture of Blockchain through a monitory system based on Ethereum. They conclude saying that the supply chain can be increasingly streamlined using Blockchain, which also ensures global authenticity and security for data and information at the same time. Caro et al. [11] presented a blockchain traceability solution for agri-food supply chain using Ethereum and Hiperledger Sawtooth and making an evaluation and comparison of the performance of both. In this solution, they integrated Internet of Things devices to produce and consume digital data along the whole chain. Even with all the advantages mentioned above, it's common to see many small and medium-sized companies considering the impact of Blockchain as a threat [5]. Six challenges of Blockchain have been identified in [3] including storage capacity and scalability, privacy, leakage, high cost and regulation problems, throughput and latency issue, and lack of skills. Forrester [12] was the first to introduce System Dynamics (SD) in the early 60s as a modelling and simulation methodology for the analysis and long-term decision-making of dynamic industrial management problems. In [13] was presented the first version of the well-known

Beer Distribution Game, an experiential educational game consisting in a role playing SD model of a supply chain originally developed by Forrester. Minegishi and Thiel [14] used SD in integrated food industry to improve its complex logistic behavior understanding. Georgiadis et al. [15] adopted the SD methodology to model and analyse strategic issues such as long-term capacity planning for food supply chains.

3. Methodology

Based on literature review related in application of blockchain in food supply chain, the questionnaire was created. The study commenced with the preliminary survey to get elementary factors influencing blockchain implementation and its feedback. 72 questionnaires were sent to food quality assurance and food management professionals and 32 participants were replied. In order to clarify the concerned factors, discussions were carried out with 15 participants from food safety and food quality management expert firms. This is to select the important elementary factors to construct the Causal Loop diagram. For system dynamics simulation modelling, Causa Loop diagrams and Stock and Flow diagrams were developed using Vensim Software before the model was validated with coconut water export company.

4. Result and Discussion

The Causal Loop Diagram as a tool of dynamics approach was presented to verify screened elementary factors and Stock and Flow Diagram were extended in order to explain food supply chain dynamics influencing on blockchain implementation. The significant factors influencing blockchain implementation level includes budget for blockchain implementation, available blockchain software and hardware cost, desired traceability level, customer trust and royalty, impact of willingness to implement blockchain, expected price with traceability through blockchain. demand willing to pay for traceable food. Customer awareness level for food safety and traceability, and other factors as the model shown in Figure 1. After the model was run we found that customer awareness level for food safety and traceability is one of the important factors can affect to designation of producer to increase blockchain implementation level. And the increase of blockchain implementation level can reduce food frauds and food safety management cost. Blockchain technology helps enablers in the supply chain realize that the other players in the chain can trace and reject they if they find food frauds. The adoption of blockchain technology in support of supply chain to build transparency and traceability mechanism to strengthen the linkages in the food chain.

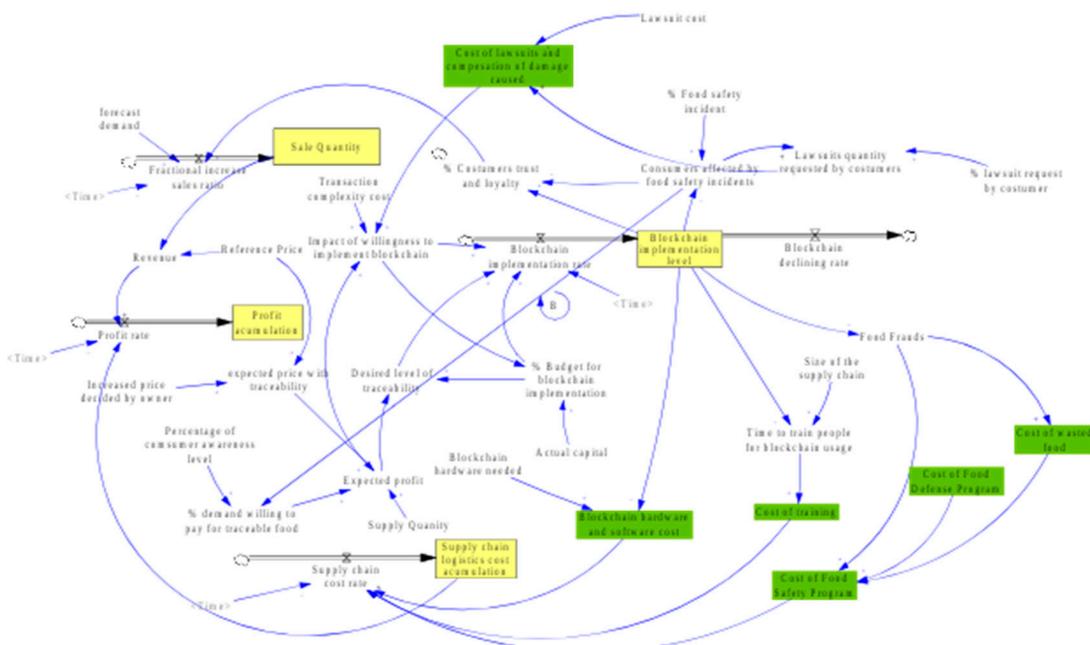


Figure 1. System Dynamics Model for Impact of Blockchain Adoption for Safe Food Supply Chain Management.

However, the proposed model is still limited because influencing factors collected from experts from food export companies. The model should be extended to discuss and validated with experts from sourcing, retailers, and distributors in which model can include more factors and make the model is closer to food logistics business dynamics.

5. Conclusions

The Causal Loop Diagram and Stock and Flow Diagram was created as System Dynamics Model provided explanation of food supply chain dynamics influencing on blockchain implementation. The trade-off, challenges and opportunities of applying block chain technology on the global food value supply chain has been well discussed throughout the system dynamics model. The major contribution of this work showed insight into some of the main dimensions of block chain technology and its implications for global food value chain performance improvements.

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