Revolutionizing Thailand's Agricultural Sector: The Transformative Potential of Blockchain Technology in Digital Economy Supportive Policy

Shinnawatra Junchairussamee* Tanpat Kraiwanit**

***PhD Student, Digital Economy, Faculty of Economics, Rangsit University, Thailand
E-mail: shinnawatra.j65@rsu.ac.th
**Lecturer, Digital Economy Program, Faculty of Economics, Rangsit University, Thailand
Corresponding author's email: tanpat.k@rsu.ac.th

Abstract

Blockchain technology is a data storage system that involves a distributed database, which is a modern technology that has garnered widespread interest and study both locally and internationally. Currently, blockchain technology has revolutionized the world of business, finance, and banking, as well as government agencies in different countries, which have elevated their management to become digital governments that align with the digital economy. This can help to facilitate and improve the lives of citizens by making services more convenient, trustworthy, transparent, and verifiable, as well as reducing the steps involved in coordinating government activities. The purpose of this article is to study the principles of blockchain technology and smart contracts, as well as to propose recommendations for their application to solve the problems of government management in the agricultural sector in Thailand, to ensure smooth and efficient operations. Blockchain technology is a new technology that has garnered interest and study both locally and internationally, and has been revolutionary in the business sector, particularly in finance and banking. Many countries have upgraded their government management systems in response to the digital technology that is expanding in all sectors of the economy, which is crucial to the running of government operations and management. In addition, it can support and assist in providing convenience for citizens to access government services quickly, efficiently, transparently, and verifiably. This study has four main points: 1) top-down decision-making, 2) income stability, 3) unintended outcomes, and 4) the motivation of politicians and government officials. The results of this study show that supporting Thailand's digital economy in the agricultural sector can be achieved through the use of blockchain technology in data management, smart contracts to influence production factors, supporting and providing various benefits to farmers, and even implementing e-voting and allocating benefits to community-related activities. This can help to collect data from these activities to use for policy development and review.

Keywords: blockchain, smart contract, digital economy, Thai agricultural

Introduction

The global economy has experienced gradual growth with fluctuations since its origins in the "linear economy." Over time, it has transitioned to a more sustainable "circular economy" (Petchkong, 2016). As economic systems have evolved, technology and society have also progressed, resulting in significant improvements that have shortened the gap between space and time and led to significant leaps in technological and social changes.

The Fourth Industrial Revolution (Singh, 2019) has introduced technology-supported work systems, which have improved production efficiency and resulted in innovative products and services. Furthermore, the ongoing shift towards the Fifth Industrial Revolution involves humans and robots working collaboratively in a "Cobots" format, with machinery and robots quickly learning new things to reduce human error (Kadir Alpaslan Demir, 2019) and increase productivity. This development indicates that the "traditional economy" is shifting towards a "digital economy," driven by innovative technologies such as Metaverse, Web3.0, AI, AR/VR, and Quantum computing (Marr, 2022). One of the innovative technologies that has gained acceptance and interest in both academia and practical applications is Blockchain (Bonson, 2019), It is a distributed accounting network that provides trustworthiness, transparency, auditability, and security in its use (Reza Toorajipour, 2022). Specifically, it prevents data deletion or alteration, particularly in large blockchain networks, thereby preventing data leakage and allowing for targeted data disclosure to specific individuals according to their designated rights (Thoppae, 2021). Overall, the gradual evolution of the global economy, driven by technological advancements, has resulted in a more sustainable and efficient economy. By adopting innovative technologies such as Blockchain, we can continue to transform the economy and drive progress.

Based on the information presented, it is clear that technology is a crucial factor that can contribute to a country's economic potential beyond its domestic resources. Therefore, equating "economic growth rate" with "economic development rate" is incorrect, as the latter is influenced by various factors, including cultural, economic, and political structures, resources, and the skills and abilities of the workforce.

Developing countries typically have medium to low levels of industrialization, income, and living standards (Ozoral, 2019) and are often classified based on their Gross National Income (GNI) and Gross Domestic Product (GDP) levels. As of 2021, the average GNI and GDP for developing countries were 232,160 baht per year (Thansettakij, 2022) and 1.6% (National Economic and Social Development Council, 2022), respectively. Thailand, for example, has been considered a developing country for more than 30 years since 1988 (Bangkokbiz, 2021). In Thailand, increasing social inequality is a persistent and severe issue, with the economy tending to grow in a "rich get richer" pattern due to four main factors. First, 31% of Thais work in agriculture but face falling agricultural product prices, resulting in low income growth and increasing inequality. Second, there is a growing inequality of opportunities, including in education, workforce, and wages. Third, there is a rising income inequality, with those earning higher incomes recovering faster from economic crises, while those working outside of the formal sector, accounting for 54% of the total workforce, do not have sufficient state welfare. Lastly, Thailand is entering a fully-fledged aging society (Lapudomkarn, 2021). While the government has policies to support farmers, they are often short-term solutions that do not directly address the increased productivity of the workforce. Moreover, these policies contribute to the burden of outstanding debts under semi-fiscal discipline measures, which have accumulated to a significant amount of 257 billion baht (Mahathanaseth, 2021). Given these issues, it is worth considering whether blockchain technology can support government policies in developing and addressing these issues. This technology can help Thailand's agriculture compete and access state welfare mechanisms equally, ensure transparent and stable income distribution, reduce corruption between government agencies, and distribute political and treasury power to local communities appropriately. By doing so, it can prepare the backbone of the nation, which is the farmers, to face the Industrial Revolution 5.0 in line with the digital economy system.

Blockchain technology under consensus algorithms

Blockchain technology is a data storage system that continuously increases its distributed database. It records data in a coded format and is controlled by a mechanism that ensures the accuracy of the data on every device connected to the blockchain network (node). The recorded data is in the form of a public ledger, and since blockchain is a decentralized system, it does not rely on a central authority. Participants in the network hold the same data and verify it together, making it difficult to alter or duplicate the data. The data is arranged systematically in a data box format called a block, which is linked together in a chain structure. Each block includes a reference to the previous block (previous block hash), the data version, the timestamp, a hash reference, a unique number (nonce), and a validation of the data (Merkle root), in that order. Each block links to the transactions of the previous block (XuWang, 2019) through its hash reference, which makes it challenging or impossible to alter the data due to the unique and one-way function of the cryptographic hash function used to generate the hash reference.

The structure and operation of the blockchain system are illustrated in Figures 1 and 2. Blockchain technology is reliable, transparent, verifiable, and highly secure, and transactions processed (Hayes, 2022) through it are efficient and cost-effective. Additionally, smart contracts can be used to define various conditions and rules, allowing for the automation and execution of agreements between parties (Suepaisal, 2021). Here are some examples of how blockchain technology is being used in different industries or applications.

1) Supply Chain Management: Blockchain technology is being used to track products from their origin to the end consumer, ensuring that they are genuine and of high quality. This helps to prevent fraud and counterfeiting, as well as improve transparency and accountability (Dutta, Choi, Somani, & Butala, 2020).

2) Healthcare: Blockchain technology is being used to create secure and easily accessible medical records, which can be shared between healthcare providers and patients. This can help to improve patient care, reduce costs, and increase efficiency (Agbo, Mahmoud, & Eklund, 2019).

3) Banking and Finance: Blockchain technology is being used to facilitate secure and transparent financial transactions, reducing the need for intermediaries and increasing speed and efficiency (Zolfaghari, Daly, Nasiri, & Sharifian, 2018).

4) Real Estate: Blockchain technology is being used to digitize the entire process of buying and selling real estate, from property listings to mortgage applications to title transfers. This can help to reduce costs, increase transparency, and streamline the process (Le & Hsu, 2021).

5) Identity Verification: Blockchain technology is being used to create secure and tamper-proof digital identities, which can be used for authentication and verification purposes in various industries (Nusantoro, Supriati, Azizah, Santoso, & Maulana, 2021).

6) Voting Systems: Blockchain technology is being used to create secure and transparent voting systems, which can help to prevent voter fraud and increase trust in the democratic process (Pawlak & Poniszewska-Maranda, 2021).

7) Energy Management: Blockchain technology is being used to create decentralized energy grids, which can help to reduce energy waste and increase efficiency (IREANA, 2019).

Figure 1

Blockchain Structure

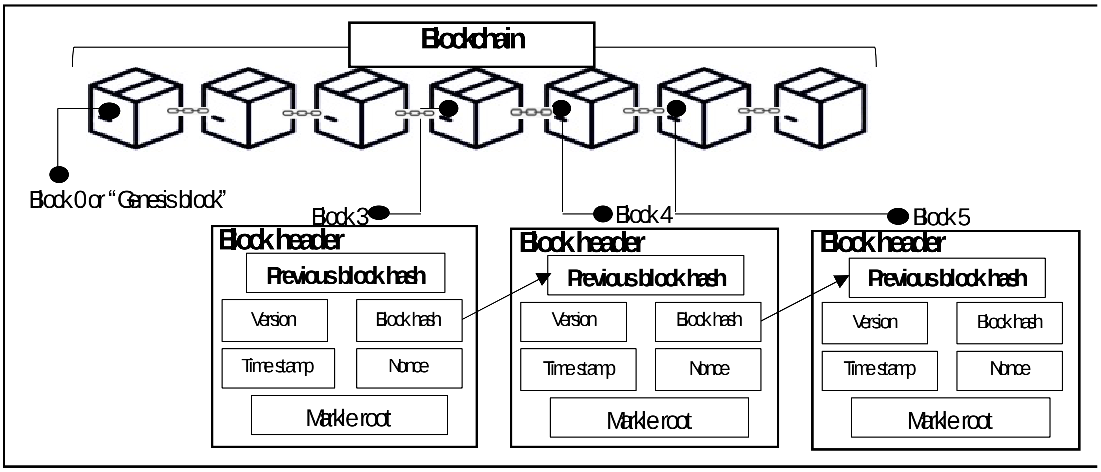
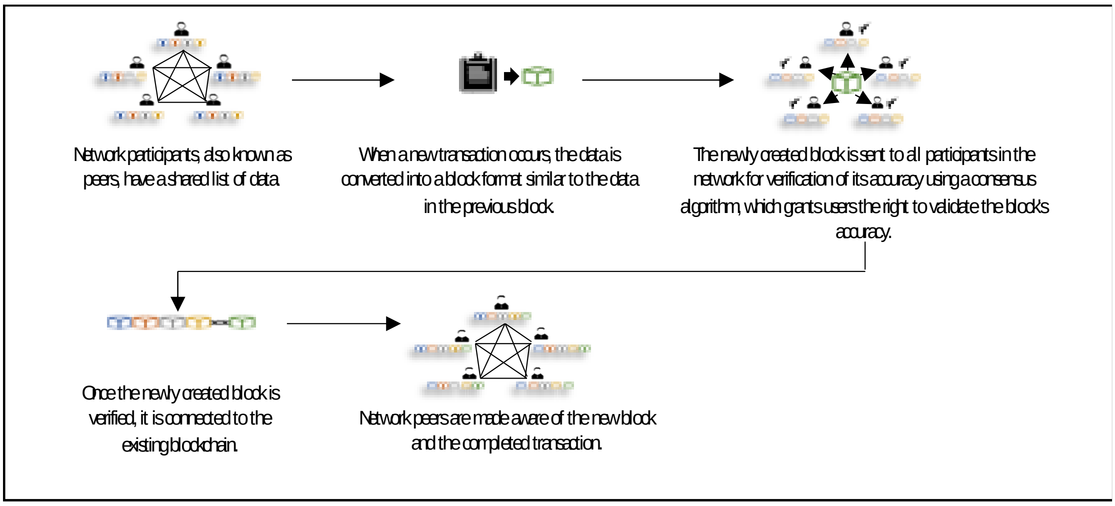


Figure 2

The operation of blockchain technology.



Note: Revised from "Understanding blockchain technology" (Sarmah, 2018)

Types of Blockchain

Blockchain technology is a decentralized and distributed ledger system that enables secure and transparent transactions without the need for a central authority. It is renowned for its reliability, transparency, verifiability, and high level of security. The blockchain system consists of blocks that contain data about processed transactions on the network. Each block is linked to the preceding and subsequent blocks, forming a chain of blocks, hence the name "blockchain".

There are four types of blockchain (Mohammad wazid, 2020) :

1) Public blockchain is entirely decentralized and open to anyone with internet access and registered as a node on the blockchain network. Transactions are recorded and verified by network nodes, requiring a consensus algorithm to determine transaction validity. Public blockchain is commonly used for digital currencies, but it has a disadvantage of taking longer to process transactions.

2) Private blockchain is a distributed ledger system operating within a closed network, where a single entity or authority controls access and permissions. Compared to public blockchain, it offers faster verification of transactions due to its partially decentralized nature. Private blockchain is commonly used in organizations with shared interests, such as

supply chain management or in specific industries such as finance, healthcare, or logistics. Examples of private blockchain platforms are Multichain and Hyperledger(A) (Apoorva Mohite, 2018).

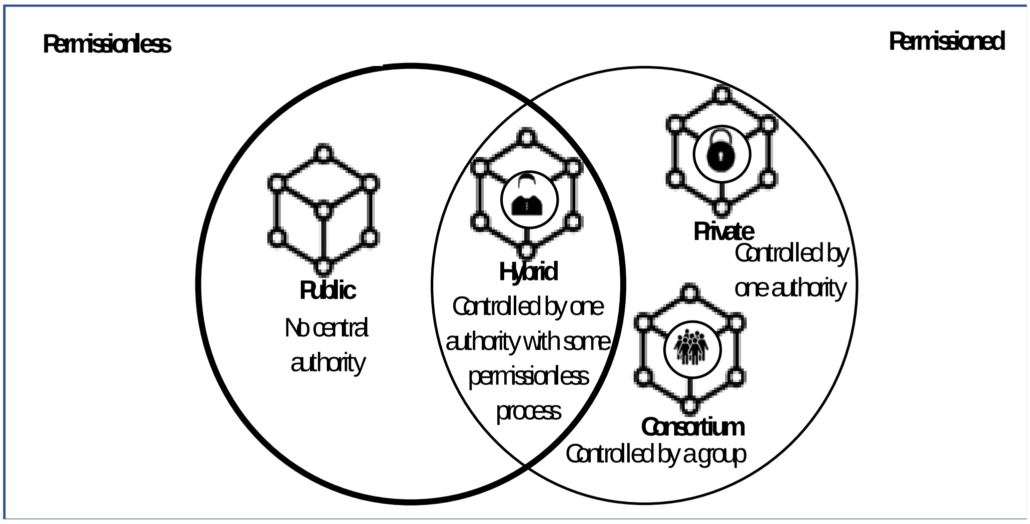
3) Consortium blockchain is a semi-decentralized system involving multiple parties with varying levels of control. It is commonly used in industries that require collaboration and cooperation between multiple parties, such as banking, transportation, and energy. Consortium blockchain offers convenience and cost savings to all parties involved. Examples of consortium blockchain platforms include the leading global energy company group and the consortium group (R^3).

4) Hybrid blockchain combines the features of both public and private blockchains. It is used when a balance between transparency and privacy is necessary, and network participants require different levels of access and control over permissions. Hybrid blockchain has a shorter transaction processing time than public blockchain and provides a high level of security and transparency (Saide Zhu, 2020). Examples of hybrid blockchain platforms include Dragonchain(B) (Peterson, 2017) and IBM Food Trust(C) (IBM, 2020), among others.

Understanding the different types of blockchain is crucial in determining the best-suited blockchain for a particular use case. The choice of blockchain type depends on the specific needs of users, such as the level of security and transparency required, the number of parties involved, and the level of control each party requires.

Figure 3

Types of Blockchain

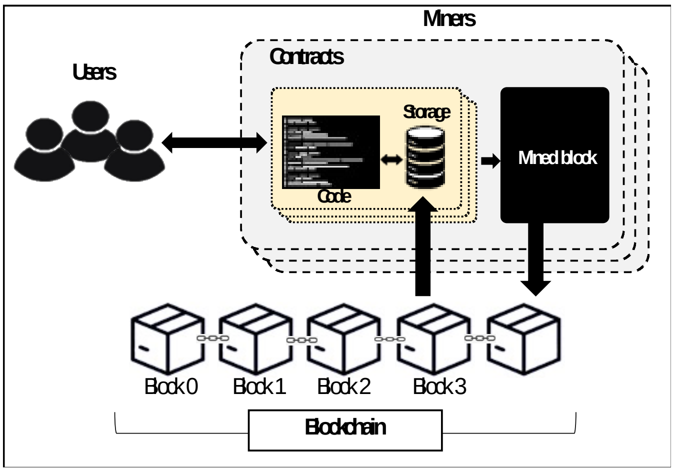


Note: Revised from "Types of blockchain: Public, private, or something in between" (Kathleen E. Wegrzyn, 2021)

Smart Contract

Smart contracts were conceptualized by Nick Szabo (Szabo, 1997), who developed a set of computer program commands to control data sets on a blockchain system (Zibin Zheng, 2020). The purpose of smart contracts is to automate the execution of conditions and agreements in a decentralized system. When combined with blockchain technology, smart contracts can create desirable P2P features, as mentioned earlier. However, smart contracts can be written in several languages, depending on the blockchain system used. For example, Ethereum uses Solidity as its primary language. Once the contract is written and deployed on the blockchain, it receives a contract address that cannot be changed. The blockchain system recognizes this address as belonging to a specific contract. When the smart contract is used, the user (contract party) requests data using the contract address to enter the contract data. After that, the data is sent to the miner, who runs the program using the address data to execute the smart contract and record the data in the block. Each time the block is distributed, the miner changes, and a new miner takes over to run the program to confirm the results. Finally, the data is accepted into the blockchain (Panwilai, 2018). This process is illustrated in Figure 4.

Figure 4
The Operation of Smart Contract



Note: (A) Multichain and Hyperledger are distributed database technologies that combine the benefits of open-source technology and allow organizations to have control without seeking profit as a central authority.
(B) Dragonchain is a blockchain system developed by The Walt Disney Company. The system is designed to be more private than public blockchains, with the advantage of a digital ledger that cannot be tampered with. Additionally, businesses can choose not to disclose certain information.
© IBM Food Trust is a blockchain system developed by IBM in collaboration with retailers, supermarkets, and leading food industry companies such as Walmart, Nestle, Dole Food, and Unilever. The system is used to trace the origin of food products, providing increased transparency and accountability within the food supply chain.

Note: Revised from "A Triplicate smart contract model using blockchain technology" (Peter U. Eze, 2017)

Using Blockchain Technology to Support Thailand's Agricultural Sector in its Digital Economy Policy

Blockchain technology is a decentralized management system with distinct characteristics and features that ensure high transaction accuracy while reducing the number of steps and time required for work processes. Furthermore, it minimizes the risk of system-wide failure that can occur with a single point of failure. Many countries have embraced blockchain technology to drive their government initiatives (Bustamante P, 2022) because government work is collaborative in nature and requires data sharing and unique work processes (Sekkhuntod, 2017). Nevertheless, the Cato Institute has identified four problems with government administration that could be addressed using blockchain technology (Edwards, 2015).

Top-Down Coercion

The governance of state policies related to the Thai agricultural sector is often characterized as employing a top-down approach, wherein policies are dictated by those in power and following the Elite Model, which assumes that public policy reflects values allocated by leaders or the group in power, rather than reflecting the actual needs of farmers and the agricultural market. Although the Ministry of Agriculture and Cooperatives (2560) has attempted to address weaknesses and reinforce strengths in the agricultural sector by prioritizing various contexts related to agriculture or adopting a bottom-up approach, it has been found that household debt of farmers increased by 74 percent from 2561 to 2565, owing to expenses outside of the agricultural sector and debt from production factors (Pongthong, 2022). The state has insufficient information, such as a lack of market data, to effectively drive policies that yield results, similarly to several projects that provide empty funding to farmers, which may use inadequate cost-benefit analysis data, leading to complicated work processes, creating financial burdens on the government, and negatively impacting farmers' motivation (Chantarat, 2019). Moreover, the complex linkage structure of the organizations under the Ministry of Agriculture and Cooperatives creates difficulties in registration processes and obtaining various rights from overlapping state policies, resulting in high costs between government agencies (Bhakdinarinath, 2020).

Funding Guarantees

When farmers make decisions about crop cultivation, livestock raising, agricultural product harvesting, or the usage of production factors, it directly impacts their income. Ultimately, farmers may face an overwhelming amount of debt that cannot be resolved due to their depleted development capital. This creates a mechanism of creative destruction, which refers to the continuous evolution of industries, revolutionizing the structure of the economy by destroying old structures and creating new ones (Schumpeter, 2020). This situation may provide opportunities for middlemen or more efficient and consumer-responsive capitalists to survive in the market and transfer resources, such as capital and labor, to more promising businesses. However, this can also lead to income degradation and quality of life issues (Duangnirath, 2021). Although the government may also make such mistakes, it has a stable source of income from taxes, which is somewhat linked to the efficiency of policy implementation, creating a small feedback loop between farmers and the market/consumers. This implies that producers and consumers are the key drivers of efficient private sector organizations that must improve their efficiency and measure the results of their budget usage (Edwards, 2015).

Unintended consequences

The economic role of the government is to promote economic growth and intervene in the economy through private sector economic functions (Misomnai, 2021). These functions may include setting minimum and maximum prices, as well as collecting taxes (Unwieng, 2021), with the aim of maintaining economic stability. However, unintended consequences may arise from these functions, ultimately harming society as a whole. For instance, the price guarantee program for agricultural products or providing empty subsidies to farmers, as mentioned above, can result in farmers taking risks without alternatives, leading to undesirable outcomes. Other examples include the importation of shrimp that harms farmers (Thairath, 2022), the Rice Trading Act, B.E. 2018 that limits production factors (BiothaiTeam, 2019), and dam construction that causes water shortages for farmers (Thairath, 2023). These consequences may be attributed to insufficient data and a lack of coordination between government agencies, resulting in the implementation of government plans from a broad perspective without adequately considering the long-term needs of farmers. Such unintended outcomes can be a risk to the government's image, as multiple measures and standards may be perceived as opaque.

Political incentives

The political incentives of politicians and state officials play a pivotal role in the equitable distribution of public benefits. The term "public benefit sharing" is commonly used in economics to refer to the allocation and distribution of benefits among private entities, while in the context of government, it refers to benefits that enhance the overall well-being of society, as defined by Black's Law Dictionary (Black, 1991). Such benefits may include financial gains or may impact the rights and legal responsibilities of the majority of citizens. Public benefits are a collective outcome of government operations at the local, regional, or national level (Black, 1991). Democratic governments may fail to meet the expectations of their constituents due to the distribution of public benefits. Political leaders may be more inclined to prioritize personal gain, such as securing their position in the next term, which can lead to the adoption of short-term benefit distribution policies that overlook the long-term costs. This can result in a loss of trust in the government (Clifford, 2020). In Thailand, more than 70% of farmers surveyed expressed discontent with the government's efforts to improve the agricultural sector (Thongsuwan, 2020). Additionally, voters may not be cognizant of or concerned about the consequences of policies and may base their votes on their feelings towards political parties rather than policy proposals (Caplan, 2008). This may be attributed to the fact that evaluating the effectiveness, productivity, and operations of the government/bureaucracy is more intricate and challenging to comprehend than in the private sector, which has clear benchmarks of business performance.

Blockchain technology offers several advantages, including reducing the importance of intermediaries and facilitating comprehensive, accurate, transparent, and verifiable management of data. As a result, it can significantly aid in managing the feedback loop that reflects policy results, enabling governments to effectively evaluate the effectiveness of their operations (Department of Intellectual and Property, 2021). The four critical elements of the blockchain system's data components are: (a) registration records, (b) identity verification systems, (c) smart contract creation, and (d) payment systems. To address specific cases, several governments have already implemented blockchain technology, adapting it to their particular needs and effectively solving real-world problems (Pandey, 2020). These applications include:

1) Proof of ownership and transfer: Governments have used blockchain technology to store data related to transactions such as land, real estate, and vehicles in the public ledger. In Georgia, for example, this approach has reduced paperwork and increased transparency, improving the public's understanding of government operations.

2) Self-executing contracts: In Sweden, self-executing smart contracts have been used to manage land transactions, significantly reducing intermediaries and increasing transparency, resulting in a transaction time reduction of up to 90%. Some industries have also established associations that use smart contracts to conduct cross-border business transactions efficiently.

3) Social benefit management: Governments have used blockchain technology to manage social welfare benefits, such as unemployment benefits in the Netherlands. This technology ensures that data records cannot be manipulated by unauthorized individuals or groups, increasing the security and reliability of the information. Governments are also designing blockchain architectures for project management, reducing the costs of conducting government operations.

4) Validation of documents: Blockchain technology can ensure the validity of records in validating documents, which can be stored in the cloud to ensure transparency and easy access by authorized parties. For instance, MIT has issued blockchain-based certificates that enhance transparency in grading student scores while reducing the need for intermediaries in the certification process (Narktong, 2017).

5) Patent protection: Blockchain technology can aid in patent protection by providing a timestamp component that allows individuals and companies to register patents instantly in the blockchain system. This feature reduces the time required to register and provides an immutable record that can prevent costly legal disputes.

The principles of blockchain technology can be effectively applied to support multiple dimensions of public policy. These principles emphasize the reduction of intermediary influence and the ability to comprehensively, accurately, transparently, and verifiably manage data. When combined with government mechanisms, blockchain can become an essential tool to propel Thailand's agriculture according to the national strategy. This approach will cover various issues, tasks, and areas of work at all levels, aligning with the objectives stated. Additionally, it can provide a direction for coordination among various sectors, including government, private, civil society, academic, agricultural, and others, in a transparent manner (National Economic and Social Development Council, 2022). This approach enables tracking the results achieved at every level and allows public participation, monitoring, evaluation, and ultimately building trust between the public and private sectors, resulting in a sustainable agricultural sector with abundant resources and farmers.

Blockchain technology, far from being merely a contemporary terminological trend, harbors the potential to fundamentally reimagine public policy approaches, particularly within the domain of digital agriculture. Leveraging the quintessential principles, diverse types, and integral components of blockchain enables the crafting of more impartial policies, which not only yield equitable outcomes for all stakeholders but also judiciously address concerns pertaining to fiscal and beneficial aspects. This methodology is not strictly theoretical in nature; it finds pragmatic application in Thailand's National Strategy for the 20-year period spanning from 2018 to 2037, which aspires to augment the well-being of agricultural practitioners and fortify public confidence in governmental entities. This scenario transcends mere speculative hype, as there have been tangible real-world applications of blockchain that have substantiated various public policies across governmental and private sectors. An exploration into these international studies and a meticulous analysis of their respective successes can elucidate possible trajectories for the application of blockchain in buttressing digital agriculture policies in Thailand. Table 1 synthesizes some of these potential directions and proffers a roadmap for employing blockchain technology to sculpt a future that is both sustainable and equitable for Thai agriculturalists and the general populace.

Table 1

Directions for the Application of Blockchain Technology in Supporting Digital Agriculture Policies in Thailand

Perspectives on government administration	Problems	Using blockchain technology to solve problems	Blockchain types	Related research
1. Top-Down Coercion	1. Insufficient data hinders the ability to analyze and formulate precise agricultural policies. 2. The complex organizational structure affects the utilization of agricultural services by farmers.	1. Data record management for effective administration.	Consortium blockchain	Heng Hou (2017); Alketbi, Nasir and Talib (2020); Lazuashvili, Norta and Draheim (2019); Jansen and Ølnes (2017)
2. Funding Guarantees	1. The middleman problem/agricultural contract farming constrains agricultural production factors and results in high prices. 2. The issue of social inequality exacerbates the problem.	1. Data record management for effective administration. 2. Using Smart Contract 2.2 Intervention to control production factor prices 2.3 Provide financial literacy to farmers before receiving government support in various areas 2.4 Provide rights/welfare according to government policies	Consortium blockchain	Jian Xu, Yongrui Duan (2021); Tripoli, M. and Schmidhuber, J. (2018); Berg A., Markey-Towler B. and Novak M. (2020); Meng Han et.al. (2018); Malvern (2016); Hsu, Ching-Sheng, Shu-Fen Tu, and Zhao-Ji Huang (2020)
3. Unintended consequences	1. Government policies have a non-transparent and non-participatory impact on farmers. 2. Fragmented government agencies lead to a lack of information for policy improvement.	1. The e-vote system for conducting public polls and critiques. 2. Data record management for effective administration.	Consortium blockchain	Pankaj Joshi, Sachin Kumar, Divya Kumar, Anil Kumar (2019); Ebizimoh Abodei et. al. (2019); Rumeysa Bulut, Alperen Kantarcı, Safa Keskin, Şerif Bahtiyar (2019)
4. Political incentives	1. The allocation of public benefits does not conform to the designated context or is unsuitable for the local context.	1. The e-vote system for conducting public polls and critiques. 2. Data record management for effective administration.	Consortium blockchain	Sarah Al-Maaitah, Mohammad Qatawneh, Abdullah Quzmar (2021); Friðrik Þ. Hjálmarsson, Gunnlaugur K. Hreiðarsson, Mohammad

Perspectives on government administration	Problems	Using blockchain technology to solve problems	Blockchain types	Related research
	2. Lack of transparency (in voting).			Hamdaqa and Gísli Hjálmtýsson (2018); Lyna Miloudi, Khaled Rezeg, Okba Kazar and Mohamed Kotoub Miloudi (2020)

Blockchain technology has emerged as a promising tool that could revolutionize the way we approach public policy, particularly in the realm of digital agriculture. This potential has not gone unnoticed by the Thai government, which has already integrated blockchain into its 20-year national strategy (2018-2037), with the aim of improving the well-being of farmers and increasing public confidence in the government. As outlined in Table 1, blockchain can help design more equitable policies that address concerns around costs and benefits, delivering outcomes that are fairer for all stakeholders. Drawing from successful implementations of blockchain technology to support various public policies across government and private sectors, we can identify possible directions for applying blockchain to support digital agriculture policies in Thailand.

One significant advantage of blockchain technology is that it can facilitate effective data management and analysis of various factors related to policy implementation. For example, it can enhance the income of farmers who practice organic farming by enabling them to sell carbon credits to various industries (Yuting Pan et.al., 2019). Tokenization[5] can be used to implement various agricultural welfare policies that support farmers transparently and reliably (Ricardo, Nunzio and Rodrigo, 2021), providing a practical solution to execute policies while preventing data leakage and linking policy with government operations more efficiently.

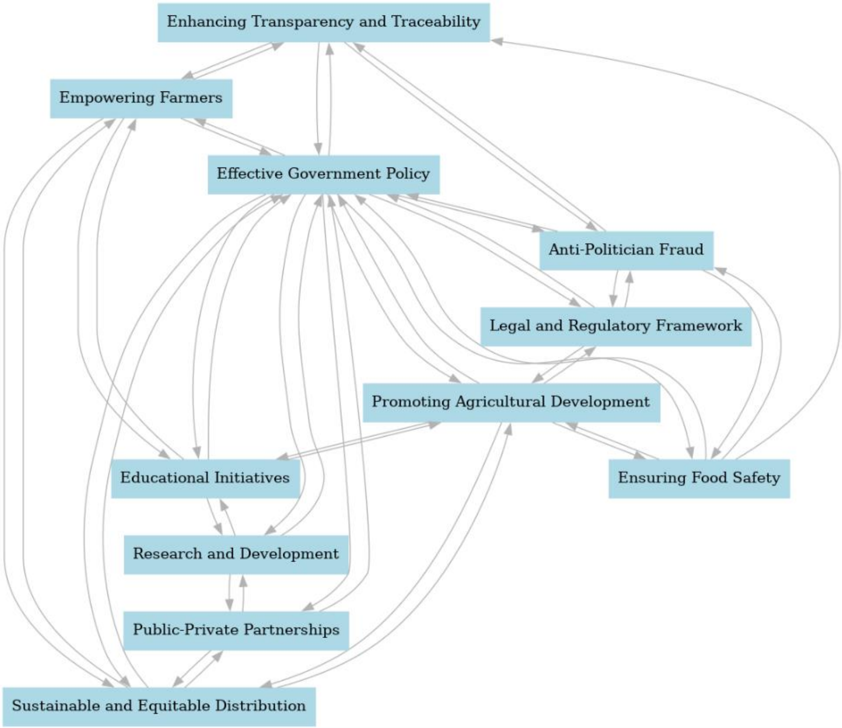
Despite its potential benefits, the use of blockchain technology to support digital agricultural policies in Thailand is still vulnerable to challenges such as attitudes, knowledge, and related equipment for using the system. Nonetheless, with the government's recognition and investment, we can expect significant advancements in this area, realizing the potential of blockchain to facilitate more equitable and effective digital agricultural policies in Thailand.

Conclusion

After thorough consideration, we can confidently assert that blockchain technology has the potential to revolutionize the way public policy is approached, particularly in the context of digital agriculture. The Thai government has already recognized the benefits of blockchain technology and has integrated it into its 20-year national strategy (2018-2037) aimed at boosting farmers' well-being and increasing public confidence in the government. By leveraging blockchain technology, critical issues in government management, such as top-down decision-making, income stability, unintended consequences, and political and bureaucratic motivation, can be addressed. Specifically, blockchain can support Thailand's digital agricultural policies through data management, smart contracts, and e-voting systems. Our research has compiled and analyzed data and approaches related to blockchain technology, providing valuable directions for supporting digital agricultural policies in Thailand. Implementation of blockchain technology can lead to equitable access to state welfare mechanisms, transparent income distribution, and reduction in corruption among organizations. Furthermore, decentralization of political and fiscal power to the local level can enable sustainable responses to the challenges posed by Industry 5.0 under the digital economy system.

Figure 5

Visualizing Blockchain's Impact on Thai Agriculture and Government Policies



In conclusion, the exigency of assimilating blockchain technology into Thailand's digital agricultural policies is underscored by an imperative to engender sustainable development within the sector and adeptly navigate the multifarious complexities inherent in governmental management. The diagram, meticulously delineated in antecedent discussions, illuminates the symbiotic and multifaceted impacts embedded within various thematic constructs, such as transparency enhancement, farmer empowerment, and food safety assurance, inter alia. Each thematic node, whilst operating as a discrete entity, is inextricably interwoven with its counterparts, crafting a tapestry that elucidates the mutual impacts and growth trajectories within the agricultural and governmental spheres. The palpable benefits derived from blockchain technology, buttressed by governmental recognition and fiscal investment, pave the way for anticipated advancements within this domain. Ergo, this research, through its analytical narrative and visually representative diagram, seeks to carve out a niche within the academic discourse surrounding blockchain technology and its prospective applications in public policy, with a particular lens focused on digital agriculture. This exploration, whilst providing a technological roadmap, also acts as a catalyst, propelling holistic and sustainable development, steering policy, safeguarding fairness, and nurturing grassroots growth within Thailand's agricultural sector, thereby offering a holistic, interconnected panorama of the integrated impacts emanating from blockchain implementation.

Suggestion

To further advance the development of digital agriculture policies in Thailand and address the challenges posed by traditional government management, various government agencies should coordinate their efforts to foster learning and create blockchain-based prototypes alongside the Ministry of Agriculture and Cooperatives. These agencies include the Digital Economy Promotion Agency (DEPA) Thailand, the Electronic Government Agency (Public Organization) (DGA), and the Ministry of Digital Economy and Society (MDES) Thailand. Additionally, training and development programs should be implemented to enhance the knowledge and skills required to efficiently utilize blockchain systems, ensuring their effectiveness and sustainability.

Collaboration between relevant agencies and the Ministry of Education is crucial to equip the next generation of farmers with the knowledge and capabilities to leverage blockchain technology and support the digital economy. It is essential to address the limitations faced by farmers, particularly in terms of technological knowledge and blockchain system design, and ensure equal distribution of benefits among all stakeholders involved.

In conclusion, this study provides valuable insights into the potential of blockchain technology to support digital agriculture policies in Thailand. Through coordinated efforts and education initiatives, government agencies can ensure the sustainable and equitable distribution of benefits from blockchain technology, providing long-term solutions to pressing issues facing government management and promoting agricultural development in Thailand. These recommendations can serve as a valuable guide to policymakers and researchers interested in advancing the use of blockchain technology in public policy, particularly in the context of digital agriculture.

References

Agbo, C. C., Mahmoud, Q. H., & Eklund, M. J. (2019). Blockchain Technology in Healthcare: A systematic Review. *Healthcare 2019, 7*(2), 56. Retrieved from https://doi.org/10.3390/healthcare7020056

Alketbi, A. N. (2020). Novel blockchain reference model for government services: Dubai government case study. *International Journal of System Assurance Engineering and Management*, 1170-1191. Retrieved from https://doi.org/10.1007/s13198-019-00926-9

Apoorva Mohite, A. A. (2018). Blockchain for government fund tracking using Hyperledger. *International Conference on Computational Techniques, Electronics and Mechanical Systems*, 231-234. Retrieved from https://doi.org/10.1109/CTEMS.2018.8466008

Bangkokbiz. (2021, February 22). *What has been developed in Thailand for the past 30 years?* Retrieved from https://bit.ly/3BCOZ0e

Bank, T. W. (2021). *World Bank Country and Lending Groups*. Retrieved from https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

Berg A., M.-T. B. (2020). Blockchains = Less Government, More Market. *The Journal of Private Enterprise, 35*(2), 1-21. Retrieved from https://doi.org/10.17764/1930-620X.1805

Beyondyaovy. (2022). *Benefits and allowances in netherland*. Retrieved from https://bit.ly/3Pym3MO

Bhakdinarinath, S. (2020). *Challenges in providing relief to those impacted by the COVID-19 crisis in the agricultural sector.* Retrieved from https://bit.ly/3uXzYSM

BiothaiTeam. (2019). *Farmers' Right*. Retrieved from https://bit.ly/3GULg0A

Black, H. C. (1991). *Black's law dictionary with pronounciations.* United States: West Group.

Bonson, E. &. (2019). Blockchain and its implications for accounting and auditing. *Meditari Accountancy Research., 27*(5), 725-740. Retrieved from https://doi.org/10.1108/MEDAR-11-2018-0298

Bustamante P, C. M. (2022). Government by code. *Frontiers in blockchain, 5*(869665), 1-15. Retrieved from https://doi.org/10.3389/fbloc.2022.869665

Caplan, B. (2008). *The myth of the rational voter.* New Jersey: Princeton University. Retrieved from https://doi.org/10.1515/9781400828732

Cato. (2022). *About*. Retrieved from https://bit.ly/3PwtR1e

Chantarat, S. (2019). Farms, Farmer and Farming: A Perspective through Data and Behavioural Insights. *World Politics*. Retrieved from https://bit.ly/3KGyvb9

Clifford, C. (2020). *I don't plan to vote ever again*. Retrieved from https://cnb.cx/3Wim4qi

Department of Intellectual and Property. (2021). *Blockchain : Reinvent Service Delivery.* Bangkok: Ministry of commerce.

Duangnirath, B. (2021). *Agriculture as an alternative and survival option*. Retrieved from https://bit.ly/3UTNDVK

Dutta, P., Choi, T.-M., Somani, S., & Butala, R. (2020). Blockchain technology in supply chain operations: Applications, challenges and research opportunities. *Transportantion Research Part E: Logistic and Transportation Review, 142*, 1-33. Retrieved from https://doi.org/10.1016/j.tre.2020.102205

Ebizimoh Abodei, A. N. (2019). Blockchain Technology for Enabling Transparent and Traceable Government Collaboration in Public Project. *Digital Transformation for a Sustainable Society in the 21st Century, 11701*, 464-475. Retrieved from https://link.springer.com/chapter/10.1007/978-3-030-32497-1_38

Edwards, C. (2015). Why the federal government fails. *Policy analysis, 777*. Retrieved from https://doi.org/10.1177/0888406415608866

Friðrik Þ. Hjálmarsson, G. K. (2018). Blockchain-Based E-Voting System. *1th International Conference on Cloud Computing (CLOUD)*, 983-986. Retrieved from https://doi.org/10.1109/CLOUD.2018.00152

Harshita, S. M. (2021). *Blockchain technology: concepts, components, and cases.* India: IGI Global. Retrieved from https://doi.org/10.4018/978-1-7998-5787-9

Hayes, A. (2022). *Blockchain facts: what is it, how it works, and how it can be used*. Retrieved from https://bit.ly/3FSeLAc

Hou, H. (2017). The Application of Blockchain Technology in E-Government in China. *017 26th International Conference on Computer Communication and Networks (ICCCN)*, 1-4.

Hsu, C.-S. S.-F.-J. (2020). Design of an E-Voucher System for Supporting Social Welfare Using Blockchain Technology. *Sustainability, 12*(8), 3362. Retrieved from https://doi.org/10.3390/su12083362

IBM. (2020). *IBM Supply Chain Intelligence Suite: Food Trust*. Retrieved from https://ibm.co/3hpNJXA
IREANA. (2019). *Innovation lanscape brief: Blockchain, International Renewable Energy Agency, Abu Dhabi.* IRENA.
Jansen, S. Ø. (2017). Blockchain Technology as s Support Infrastructure in e-Government. *International Conference on Electronic Government, 10428*, 215-227. Retrieved from https://doi.org/10.2172/1556888
Jian Xu, Y. D. (2021). Pricing and greenness investment for green products with government subsidies: When to apply blockchain technology? *Electronic Commerce Research and Applications, 51*, 101108. Retrieved from https://doi.org/10.1016/j.elerap.2021.101108
Kadir Alpaslan Demir, G. D. (2019). Industry 5.0 and Human-Robot Co-working. *ELSEVIER B.V.*, 688-695. Retrieved from https://doi.org/10.1016/j.procs.2019.02.119
Kathleen E. Wegrzyn, E. W. (2021). *Types of blockchain: Public, private, or something in between*. Retrieved from https://bit.ly/3VS6QYL
Lapudomkarn, L. (2021). *Can the deep-rooted problems in Thailand be solved, and how?* Kiatnakin Phatra. Bangkok: KKP Research.
Lazuashvili, N. N. (2019). Integration of Blockchain Technology into a Land Registration System for Immutable Traceability: A Casestudy of Georgia. *Business Process Management: Blockchain and Central and Eastern Europe Forum. BPM 2019, 361*.
Le, T.-V., & Hsu, C.-L. (2021). A Systematic Literature Review of Blockchain Technology: Security Properties, Applications and Challenges. *Journal of Internet Technology, 22*(4), 789-801. Retrieved from https://doi.org/10.3966/160792642021042207012
Lyna Miloudi, K. R. (2020). Smart Sustainable Farming Management Using Integrated Approach of IoT, Blockchain & Geospatial Technologies. *Advanced Intelligent Systems for Sustainable Development (AI2SD'2019), 1103*, 340-347.
Mahathanaseth, I. (2021). *Evaluate the effectiveness of the agricultural income insurance project (rice, cassava, animal feed corn, and oil palm) and study the direction of future operations.* Bangkok: Kasetsart University.
Malvern, C. (2016). *Blockchain technology -- applications in improving financial inclusion in developing economies : case study for small scale agriculture in Africa.* MIT, Sloan School of Management. Massachusetts Institute of Technology. Retrieved from https://doi.org/ 10.7916/D8B01C3F
Marr, B. (2022, October 3). *The 5 Biggest Technology Trends In 2023 Everyone Must Get Ready For Now*. Retrieved from https://bit.ly/3W3EUBG
Meng Han, Z. L. (2018). A Novel Blockchain-based Education Records Verification Solution. *19th Annual SIG Conference on Information Technology Education*, 178-183. Retrieved from https://doi.org/10.1145/3197091.3197111
Misomnai, C. (2021). *What is the government's role in the economy?* Retrieved from https://bit.ly/3UTNzFu
Mohammad wazid, A. K. (2020). A Tutorial and Future Research for Building a Blockchain-Based Secure Communication Scheme for Internet of Intelligent Things. *IEEE, 8*, 88700-88716. Retrieved from https://doi.org/10.1109/ACCESS.2020.2991234
Narktong, J. (2017). *MIT tests issuing digital diplomas via Bitcoin's Blockchain*. Retrieved from https://bit.ly/3uUyCIw
National Economic and Social Development Council. (2022, February 21). *The Thai economy in the fourth quarter of the year 2021, as well as the trend for the year 2022.* Retrieved from https://bit.ly/3BA3Bh2
Nusantoro, H., Supriati, R., Azizah, N., Santoso, N. P., & Maulana, S. (2021). Blockchain Based Authentication for Identity Management. *2021 9th International Conference on Cyber and IT Service Management (CITSM)*, 1-8. Retrieved from https://doi.org/10.1109/CITSM53227.2021.9577641
Ozoral, I. C. (2019). *Comparative Approaches to Old and New Institutional Economics.* Istanbul: IGI Global. Retrieved from https://doi.org/10.4018/978-1-5225-6155-2
Pandey, A. (2020). *How governments can harness the potential of blockchain*. Retrieved from https://mck.co/3YqMQhP
Pankaj Joshi, S. K. (2019). A Blockchain Based Framework for Fraud Detection. *2019 Conference on Next Generation Computing Applications (NextComp)*, 1-5. Retrieved from https://doi.org/10.1109/NextComp.2019.8757952
Panwilai, S. (2018). *Introduction to Smart Contracts on Blockchain - Because Blockchain is not just about Bitcoin*. Retrieved from https://bit.ly/3Pra1ol
Pawlak, M., & Poniszewska-Maranda, A. (2021). Trends in blockchain-based electronic voting systems. *Information Processing and Management, 58*(4), 102595. Retrieved from https://doi.org/10.1016/j.ipm.2021.102595
Petchkong, S. (2016, July 29). *Unlock Productivity Lesson*. Retrieved from https://bit.ly/3YrqmgY
Peter U. Eze, C. R. (2017). Triplicate smart contract model using blockchain technology. *Circulation in computer science*, 1-10. Retrieved from https://doi.org/10.1186/s40649-017-0033-3
Peterson, B. (2017). *Disney built a blockchain, and now its creators are trying to turn it into a commercial platform to compete with Ethereum*. Retrieved from businessinsider: Retrieved from https://bit.ly/3uvOwsR
Pongthong, Y. (2022). *The deep wounds of COVID-19, debt burden of farmers surges by 74% in 2021*. Retrieved from https://bit.ly/3BExw7I

Reza Toorajipour, P. O. (2022). Block by block: A blockchain-based peer-to-peer business transaction for international trade. *Technological forecasting & social change, 17*(1), 1-10. Retrieved from https://doi.org/10.1016/j.techfore.2022.122855

Ricardo Borges dos Santos, N. M. (2021). Third Party Certification of Agri-Food Supply Chain Using Smart Contracts and Blockchain Tokens. *Industrial Internet of Things in the Industry 4.0: New Researches, Applications and Challenges, 21*(16), 5307. Retrieved from https://doi.org/10.3390/s21165307

Rumeysa Bulut, A. K. (2019). lockchain-Based Electronic Voting System for Elections in Turkey. *2019 4th International Conference on Computer Science and Engineering (UBMK)*, 183-188. Retrieved from https://doi.org/10.1109/UBMK.2019.8906995

Saide Zhu, Z. C. (2020). zkCrowd: A Hybrid Blockchain-Based Crowdsourcing Platform. *IEEE Transactions on Industrial Informatics, 6*(6), 4196-4205. Retrieved from https://doi.org/10.1109/TII.2020.2978122

Sarah Al-Maaitah, M. Q. (2021). E-Voting System Based on Blockchain Technology: A Survey. *2021 International Conference on Information Technology (ICIT)*, 200-205. Retrieved from https://doi.org/10.1109/ICIT51660.2021.9518397

Sarmah, S. S. (2018). Understand blockchain technology. *Computer science and engineering, 8*(2), 23-29. Retrieved from https://doi.org/10.11648/j.computer.20180202.11

Schumpeter, J. (2020). Creative destruction in time of covid. *Business*. Retrieved from https://www.economist.com/business/2020/04/30/creative-destruction-in-a-time-of-covid

Sekkhuntod, S. (2017). *How should the government use blockchain technology effectively?* Retrieved from https://bit.ly/3UVhmxn

Singh, N. (2019, February 15). *How Can We Regulate Disruptive Technologies?* Retrieved from https://bit.ly/2T0oqgr

Suepaisal, N. (2021). *What is smart contract?* Retrieved 2022 December, from thematter: https://bit.ly/3FwZdQN

Szabo, N. (1997). *Smart Contracts: Building Blocks for Digital Markets*. Retrieved from https://bit.ly/3VSTb4e

Thairath. (2022). *The government allowing shrimp imports is harming farmers*. Retrieved from https://bit.ly/3YkSaUd

Thairath. (2022). *Deputy Permanent Secretary for Agriculture Meet and talk with a group of farmers in the Northeastern region Compensate for construction of Rasi Salai Dam*. Retrieved from https://bitly.ws/WE2D

Thansettakij. (2022, May 19). *Did the average income per capita of Thai people increase in the year 2022? And how much is it per person on average?* Retrieved from https://bit.ly/3HBfJlF

Thongsuwan, S. (2020). *82.24% of farmers say that agriculture is still an important profession for the future, and 62.68% expect their children and grandchildren to inherit the profession*. (Center for Agricultural Economic Research and Forecasting) Retrieved from https://bit.ly/3AbNCEG

Thoppae, C. P. (2021). Development of Efficient and Secured Electronic Transaction Document Interchange Architecture Framework among Public Sector with Blockchain Technology. *Information Technology Journal, 17*(1), 66-75. Retrieved from https://doi.org/10.3923/itj.2021.66.75

Tripoli, M. &. (2018). Emerging Opportunities for the Application of Blockchain in the Agri-food Industry. Retrieved from https://doi.org/10.17700/jai.2018.9.2.418

Unwieng, N. (2021). *Economic System*. Retrieved from https://bit.ly/3Wi9mrt

XuWang, X. W. (2019). Survey on blockchain for Internet of Things. *Computer Communication, 136*, 10-29. Retrieved from https://doi.org/10.1016/j.comcom.2019.01.002

Yuting Pan, X. Z. (2019). Application of Blockchain in Carbon Trading. *Energy Procedia, 158*, 4286-4291. Retrieved from https://doi.org/10.1016/j.egypro.2019.01.121

Zibin Zheng, S. X.-N. (2020). An overview on smart contracts: Challenges, advances and platforms. *Future Generation Computer Systems, 105*, 475-491. Retrieved from https://doi.org/10.1016/j.future.2019.11.021

Zolfaghari, A. H., Daly, H., Nasiri, M., & Sharifian, R. (2018). *Blockchain Application in Healthcare: A Model for Research.* Retrieved from https://bit.ly/3ogcsjT