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Blockchain in Food Traceability-an Integrated ISM and DEMATEL Approach

Shashank Ranjan [a], Jayash Rajawat [b], Pragya Amol [c], Praveen [d], Dhiraj Kumar [e], Mr. Imran [f]

[a,b,c,d,e] Student, Department of Management, Lovely Professional University, Phagwara, Punjab
[f] Professor, Department of Management, Lovely Professional University, Phagwara, Punjab

ABSTRACT

To assess the efficacy of blockchain technology in food tracking, this article proposes a combined Interpretive Structural Modeling (ISM) and DEMATEL (Decision Making Trial and Evaluation Laboratory) strategy. The blockchain-based food tracking system is developed and implemented using ISM strategy, while important variables influencing success of system are identified using DEMATEL technique.

There are a number of steps involved in the ISM method, including needs collection, analysis, design, execution, and upkeep. Information system requirements are defined and issue context is gathered during requirements collecting process. In the research process, the system's goals and limitations are determined. During the planning stage, the system's framework and user interface are planned out in great depth. In the execution stage, you'll be responsible for constructing and evaluating the system. As the system ages, it will need periodic upkeep and updates, which is what this stage is all about.

To determine what variables, affect performance of blockchain-based agricultural tracking system, the DEMATEL technique is applied. Technical practicality, financial sustainability, and societal approval are all important considerations. A plan for introducing blockchain-based food-tracking system is formulated using the findings of the ISM and DEMATEL analyses.

When applied as a whole, the suggested combined ISM and DEMATEL method can be used to assess the efficacy of blockchain technology for food tracking and isolate the variables most likely to contribute to its widespread adoption. This method can aid in creation of a reliable blockchain-based food tracking system, which in turn will help to guarantee safety of food goods and increase transparency in their provenance.

Keywords: Blockchain, ISM, DEMATEL, Food traceability.

1. Introduction

Blockchain technology has the potential to revolutionize the food traceability system by providing an immutable, decentralized, and transparent record of food products throughout the entire supply chain. By using a combination of ISM and DEMATEL techniques, it is possible to fully understand the complexity of the food traceability system and identify the key factors that need to be addressed to successfully implement a blockchain-based solution. One of the major advantages of using blockchain technology for food traceability is its ability to create a tamper- proof record of all transactions and interactions that occur throughout the supply chain. This means that every time a food product is bought, sold, or moved, a record of that transaction is added to the blockchain, creating a permanent and unchangeable record of the product's journey from farm to plate. This level of transparency and accountability can help to build consumer trust in the food system, as well as provide valuable information for food safety and regulatory compliance.

The integration of ISM and DEMATEL techniques allows for a thorough understanding of the complex relationships and interdependencies between the different actors and factors involved in the food traceability system. By using these techniques, it is possible to identify the key drivers and barriers to the successful implementation of a blockchain-based solution, as well as the impact that such a solution would have on the various stakeholders involved. This information can then be used to design and implement a blockchain solution that addresses the unique needs and challenges of the food traceability system.

In addition to increasing transparency and accountability, the integration of blockchain technology into the food traceability system can also bring significant benefits in terms of efficiency and cost savings. By automating many of the processes and tasks that are currently performed manually, such as product tracking and traceability, blockchain can help to reduce errors and streamline operations, resulting in lower costs and higher productivity.

As a whole, the food system could benefit greatly from the incorporation of blockchain technology in food tracking system due to increased openness, accountability, and effectiveness. Understanding food traceability system's intricacy and developing a blockchain-based solution tailored tosatisfy the food traceability system's unique requirements and challenges requires a combined ISM and DEMATEL strategy.

When the environment becomes more difficult, effective decision-making is always preferable. Decision-makers will always be obligated to examine complicated and ambiguous circumstances to determine the causal link of an issue and make informed decisions. It is critical to comprehend the situation to make an informed choice or act.

When there is a lot of uncertainty in the situation, the cause-effect link is important. Capturing the cause-and-effect link is a difficult endeavour. The DEMATEL method, which employs matrices or digraphs to depict the architecture of complex causative relationships, was developed initially at Geneva Research Centre of Battelle Memorial Institute. As a form of structural modeling, it is particularly useful for investigating the correlations between various parts of a system. By validating dependency among components and aiding in the construction of a map to show relative links within them, the DEMATEL can be used to explore and resolve complicated and intertwined issues. This method employs grids to categorize causal connections among components and an impact relation map to pinpoint key parts of an intricate framework. Due to its usefulness and versatility, DEMATEL's method has been widely adopted by scholars in recent years, who have applied it to problems involving complicated systems in a wide range of disciplines. Additionally, the DEMATEL has been refined for better decision-making in many circumstances due to the fact that many real-world systems contain unclear and unsure information.

To the best of our knowledge, no comprehensive review of the DEMATEL technology and its applications has been conducted. Supply networks are constantly evolving to adapt to the global market's dynamic and unpredictable developments. The increasing complexity of its constituents, as well as the quantity and types of relationships between them, is causing new issues in supply chain management, including supply. Because of the evolution of such supply chains, all functional areas of logistics management must be continually upgraded. Supply management, often known as the procure-to-pay process, is one of the most fundamental logistical procedures.

Without satisfied suppliers, it is impossible to attain cheap costs and high-quality products in today's competitive business world. As a result, selecting a capable supplier group and maintaining supply chain relationships is one of the most crucial purchasing decisions. Because various variables must be considered in the decision-making process, supplier selection is a tough and complex process. Due to increased expenses, suppliers are becoming a hurdle for enterprises. The selection of a suitable supplier, on the other hand, is critical to the success of good supply chain management. According to experts, selecting suppliers is one of the most important components of the purchasing process since it lowers costs and offers you a competitive advantage.

As a result, to acquire a competitive edge today, organizations must shift their perspective toward suppliers from enemy to partner. As a result, supply chain management necessitates a more effective and efficient evaluation of supply performance. Choosing the right supplier is an important part of reaching your supply chain management goals. To put it another way, although supplier selection affects the supply chain process, bad supplier selection affects supply chain management directly. Supply chain management is a strategy and tool for coordinating suppliers, manufacturers, warehouses, distribution hubs, and distributors to lower the supply chain's overall cost. Supply chain management begins at the manufacturing facility and ends at the point of consumption. It refers to a process in which material, information, money movement, and players interact across the whole value chain. Mismanagement of the supply chain causes unpredictability and unexpected problems. Supplier selection and assessment, which is closely linked to the supply strategy, is an element of the process. This will be the primary focus of this research.

2. Literature review

1. **J. Ravi Sankar et al (2016):** For isolating the source and effect of any problem, the decision-making trial and evaluation laboratory (DEMATEL) approach is applied. Any problem's maximum age or peak factor is determined using the Combined Effect Time- Dependent matrix (CETD). As a result, rather than finding the peak factor of the cause- effect group individually using the CETD matrix, a new model could be constructed by integrating the prominent characteristics of DEMATEL in the CETD matrix, allowing the peak factor of the cause-effect group problem to be identified concurrently. The model's validity is demonstrated by its application to the problem of aggressive conduct and engagement in violence.

2. **Akbar Alam-Tabriz et al (2014**): Supplier selection has become a vital strategic aspect for most organizations in the recent changing and dynamic environment, due to current rivalry and the necessity for collaboration among enterprises. Supplier selection is a multi- criteria problem comprising quantitative and qualitative criteria, as well as complicated linkages that may involve trade-offs and interactions. The research proposes a unique hybrid multi-criteria decision-making (MCDM) technique to account for complicated linkages and trade-offs across criteria. Given these ambiguous or unclear criteria, it is critical to use a fuzzy technique to handle the ambiguity and produce more accurate outcomes. The ANP approach for obtaining the proper weightings for each sub-criterion was created to address the issues of criteria dependency and feedback. The DEMATEL approach is used as a support tool for ANP to identify a relationship network among criteria. The TOPSIS algorithm is then used to rank all competing options based on their performance. Because of its benefits in handling issues with trade-offs-including criteria, TOPSIS has lately become standard in MCDM research for evaluating alternatives. Finally, a numerical example is provided to demonstrate how the suggested model might help solve the supplier selection problem.

3. **Agnieszka-Szmelter-Jarosz (2019):** The rising complexity of supply networks necessitates the optimization of several areas. Complex relationships between different players on multiple marketplaces point to the necessity for decision-making simplicity while remaining focused on the organization's goals and priorities. The development of multi-criteria decision-making support approaches is particularly relevant to logistics assistance, especially supply management. The DEMATEL technique, which is a traditional strategy of evaluating suppliers based on survey or interview data, is one of the most extensively utilized in this industry. The purpose of this article is to show how the supplier assessment technique is applied based on the criteria that decision-makers deem important. The variables were chosen based on the findings

of the literature study. The process for evaluating was then explained, followed by an empirical case. The article can help decision-makers in single firms and supply chains improve their evaluation methods so that they can satisfy the standards that are most important to them.

4. **Sajede Mirmousa et al (2016**): Managers must routinely assess the effectiveness of their seller selection processes because vendors can have far-reaching impacts on the success of their organizations. Therefore, 43 crucial factors were found in choosing the suppliers in this study by using library studies that spanned Persian and English resources and assessing other papers connected to this topic. After 14 factors were double-checked using the flexible Delphi method, the DEMATEL questionnaire was distributed to 11 specialists and faculty members. With the help of MATLAB and the fuzzy DEMATEL technique, an effort was made to assess the connections between indices and the rate at which the criteria for choosing vendors are important and affected by using the CFCS algorithm developed in codes. Experts, specialists, the CFCS algorithm, & fuzzy DEMATEL technique were all used to determine that financial stability index had greatest influence on the completion of the project reviewing the relationship related to the optimum choice of suppliers for Yazd universities.

5. **Burak Leblebicioğlu et al (2021**): In today's competitive corporate world, efforts to enhance supply chain management systems, which have grown in prominence during the 1990s, have become an increasingly crucial phenomenon. Attention has shifted to the health sector and efforts to reform it, particularly considering recent events. Supplier selection, which is the most basic criterion in supply chain management, as well as the criteria that decide these decisions, are among the most pressing concerns. Knowing the major criteria of pharmacies in the selection of suppliers in the health sector will assist both the players who play a part in the sectoral dynamics and the firms in today's environment, where costs are reflected in pricing and quality and service performance affect competitiveness. As a result, to call attention to the issue of pharmacy supplier selection, Fuzzy DEMATEL was utilized as a study technique, and pharmacy supplier selection criteria were reviewed.

6. **Mukesh Kumar et al (2019):** Due to global competitive advantages in a continuously changing business environment, the agile supplier selections (ASS) method has been popular in recent years. The main requirement for market fluctuations and increased customer response is sustainable agile performance requirements. As a result, adapting the ASS process is a critical necessity for overcoming market fluctuations, and it is impacted by a variety of factors. Due to numerous uncertainties of market demand, lumpy demand, and mismatch of supply and demand patterns, ASS is a key issue in Supply Chain Management (SCM), making supplier selection a challenging process in the automotive sector. It is important that inter-organization balances the effective and efficient customer demands in turbulent market demand patterns due to volatile market demand and increased customer response. The solution to this challenge will be to include human judgment skill capabilities into language scale patterns. To improve its worldwide competitiveness, ASS has used methods such as fuzzy logic and DEMATEL techniques. It uses suitable ASS performance criteria to try to keep up with the variable market demand. 14 agile supplier selection criteria were chosen with the aid of the literature review for greater influence or support for ASS procedures.

7. **Sajad Karimi Ghasem Abadi et al (2021):** The resilience approach to supply chain management is one of the techniques that firms use to survive in today's chaotic environment. Supply chain managers have discovered that rivalry between supply networks has been replaced by competition between firms. As a result, they are more interested in gaining a competitive advantage in their own supply chain than in the past. In today's risk- filled climate, a resilient supply chain is a critical competitive advantage. Supplier selection is one of the most resilient aspects of supply chains. It provides advantages like flexibility, risk management, and quick response to completed delivery orders. To develop effective criteria for resilient supplier selection, this study employed fuzzy DEMATEL based on Analytical Network Process. SAPCO Company experts took part in a two-part structure. Groups in this research 15 experts created one group to screen the criteria model, while seven experts formed another to analyse the link between criteria and categorization suppliers. According to the report, supplier risk is the most important consideration, followed by supplier flexibility and response. As much emphasis is given to the technological component, and inter-criteria are given to the capability of technology. Finally, based on the findings of this investigation, a recommendation is made to SAPCO executives.

8. **Mohamadtaghi Rahimi et al (2021**): The Intuitionistic Fuzzy Set (IFS) concepts have been shown to be highly successful in many uses areas for a more human coherent thinking under poorly specified facts and unclear information. Our study introduces a new fuzzy decision-making approach, intuitionistic fuzzy entropy measures, by combining entropy and intuitionistic fuzzy sets. In this case study, we apply the model we created, which is based on entropy, to the task of analyzing the scores of suppliers in the actual world. Additionally, an intuitionistic fuzzy entropy measure in connection to the criterion is used to create the weights for each option. The supplier with the highest total weight is selected as the finest available option.

3. ISM (Interpretive Structural Modeling)

Interpretive Structural Modeling (ISM) is a method used to analyze and structure complex systems. It is a powerful tool for understanding the relationships between the elements of a system and how they influence each other. ISM is a method that helps to identify the interdependencies between factors and their causal relationships. It can be used in a wide range of fields such as engineering, management, and social sciences.

The ISM process consists of several phases:

- Identifying the elements of the system.
- Determining the relationships between elements, which can be positive, negative, neutral or circular.

- Creating a matrix that represents the system and the relationships between elements.
- Analyzing the matrix to identify the key drivers and constraints in the system.
- Prioritizing the elements to understand which elements are the most important to address.

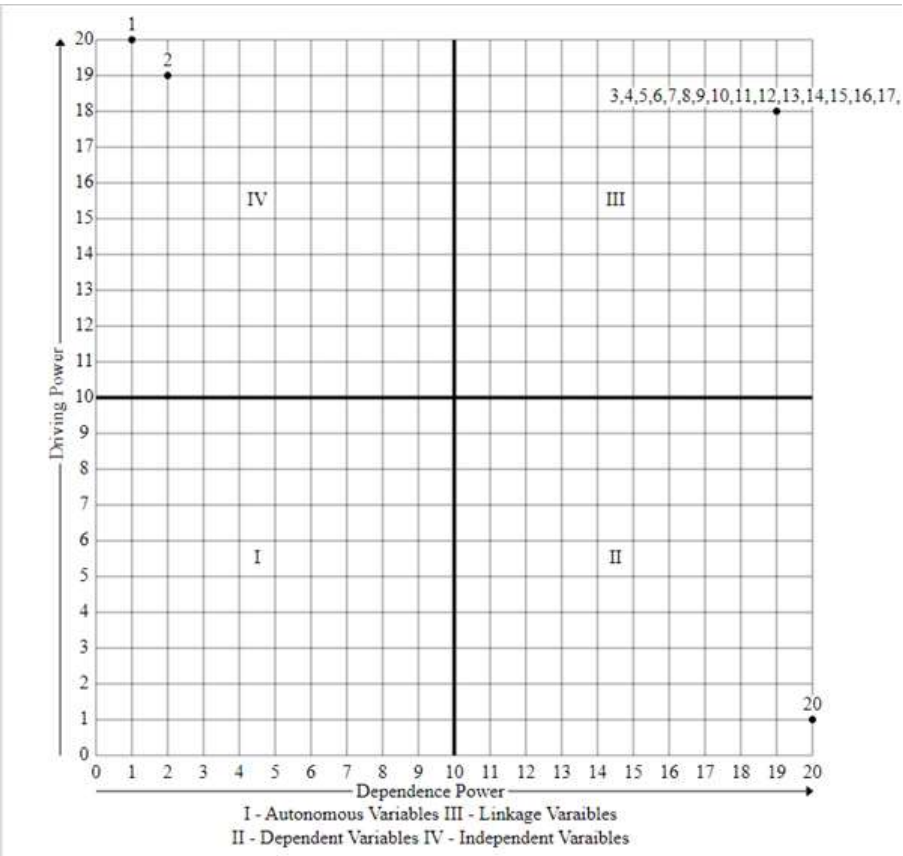
The ISM strategy can be used to evaluate a broad variety of issues, including those involving corporate structures, social systems, and technological systems, thanks to its flexibility and adaptability. ISM can be used to better comprehend the system's intricate interplay, zero in on the system's most important determinants and limits, and plan for the system's future administration and enhancement..

Structural Self-Interaction Matrix (SSIM)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Lack of Knowledge		V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Cost and Complexity			V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Lack of Standardization				V	V	V	A	V	V	V	V	V	V	V	V	V	V	V	V	V
Data Privacy and Security					V	V	V	V	V	V	V	V	A	V	V	V	V	V	V	V
Limited Knowledge and Understanding						V	V	V	A	V	V	V	V	V	V	V	A	V	V	V
Regulatory Environment							V	V	V	V	V	V	V	V	V	V	V	V	V	V
Interoperability								V	V	V	V	V	V	V	O	V	V	V	A	V
Scalability									V	V	V	V	V	V	V	V	V	V	V	V
Food Traceability Issues										V	V	V	V	A	V	V	V	V	V	V
Traceability of multi-ingredient food products											V	V	V	V	V	X	V	V	V	V
Integration with existing systems												V	V	V	V	V	V	V	V	V
Technology Scalability Issue													V	V	V	V	V	V	V	V
Possibilities of Raw Data Manipulation														V	V	V	V	V	V	V
Require all Stakeholders within a Food Supply Chain															V	V	V	V	V	V
Laws need to be Updated																V	V	V	V	V
Inefficient Process																	V	V	V	V
Food Safety																		V	V	V
Food Fraud																			V	V
Technical Challenges																				V
Lack of Standardization																				

Reachability Matrix(RM)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Driving Power
Lack of Knowledge	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20
Cost and Complexity	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
Lack of Standardization	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	17
Data Privacy and Security	0	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	16
Limited Knowledge and Understanding	0	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	14
Regulatory Environment	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
Interoperability	0	0	1	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1	0	1	13
Scalability	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	13
Food Traceability Issues	0	0	0	0	1	0	0	0	1	1	1	1	1	0	1	1	1	1	1	1	12
Traceability of multi-ingredient food products	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	11
Integration with existing systems	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	10
Technology Scalability Issue	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	9
Possibilities of Raw Data Manipulation	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	9
Require all Stakeholders within a Food Supply Chain	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	1	1	1	1	8
Laws need to be Updated	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	6
Inefficient Process	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1	1	6
Food Safety	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	5
Food Fraud	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	3
Technical Challenges	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	3
Lack of Standardization	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Dependence Power	1	2	4	5	7	6	7	8	9	11	11	12	12	13	14	16	16	18	18	20	



Level Partitioning(LP)

Elements(Mi)	Reachability Set R(Mi)	Antecedent Set A(Ni)	Intersection Set R(Mi)∩A(Ni)	Level
1	1,	1,	1,	4
2	2,	1, 2,	2,	3
3	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
4	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
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6	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
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11	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
12	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
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15	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
16	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
17	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
18	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
19	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
20	20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	20,	1

Methods for enhancing the system's performance can be devised after its primary factors and limitations have been identified through the ISM method. The ISM matrix can be used to determine which aspects of the system's technological viability need to be handled first, such as the design of more intuitive user interfaces or the implementation of stronger security protocols. Similarly, the ISM grid can be used to determine what needs to be done to increase the system's profitability, such as streamlining supply chain procedures or creating more cost-effective solutions.

Level Partitioning(LP)

Elements(Mi)	Reachability Set R(Mi)	Antecedent Set A(Ni)	Intersection Set R(Mi)∩A(Ni)	Level
1	1,	1,	1,	4
2	2,	1, 2,	2,	3
3	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
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6	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
7	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
8	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
9	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
10	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
11	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
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13	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
14	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
15	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
16	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
17	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
18	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
19	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	2
20	20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	20,	1

In the context of blockchain technology in food traceability, ISM (Interpretive Structural Modeling) can be used to analyze the complex relationships between different elements of the system, such as technical feasibility, economic viability, and social acceptability. By identifying the interdependencies between these factors and their causal relationships, the ISM approach can help to understand how different elements of the system influence each other and how they impact the overall success of the blockchain-based food traceability system.

Level Partitioning Iterations

Elements(Mi)	Reachability Set R(Mi)	Antecedent Set A(Ni)	Intersection Set R(Mi)∩A(Ni)	Level
1	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1,	1,	
2	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2,	2,	
3	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
4	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
5	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
6	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
7	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
8	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
9	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
10	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
11	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
12	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
13	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
14	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
15	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
16	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
17	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
18	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
19	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,	
20	20,	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,	20,	1
1234				

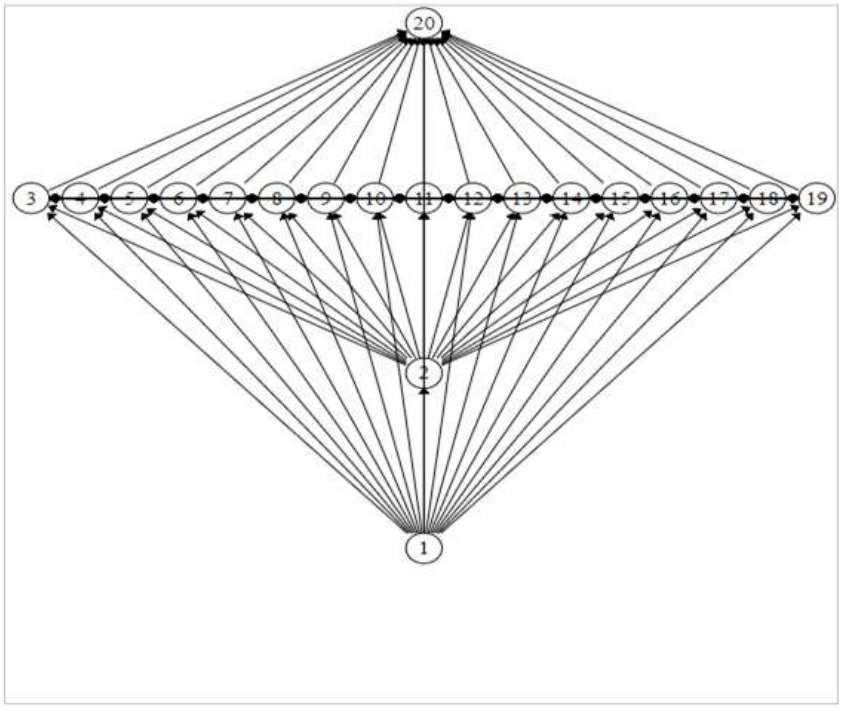
Furthermore, the ISM approach can be used to identify the key factors that need to be addressed in order to improve the social acceptability of the system, such as the need for better education and awareness campaigns or the development of more transparent and reliable systems.

Overall, the use of ISM in the context of blockchain technology in food traceability can provide valuable insights into the complex relationships between different elements of the system and can help to identify the key drivers and constraints that need to be addressed in order to improve the overall performance of the blockchain-based food traceability system.

Conical Matrix(CM)

Variables	20	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	2	1	Driving Power	Level
20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
3	1	1	1	1	1	1*	1	1	1	1	1	1	1	1	1	1	1	1	0	0	18	2
4	1	1*	1	1	1	1	1	1	1	1	1	1*	1	1	1	1	1	1	0	0	18	2
5	1	1*	1*	1	1	1	1	1*	1	1	1	1	1	1	1	1*	1	1	0	0	18	2
6	1	1*	1*	1*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	18	2
7	1	1	1*	1*	1*	1	1	1	1	1	1	1	1	1*	1	1	1	1*	0	0	18	2
8	1	1*	1*	1*	1*	1*	1	1	1	1	1	1	1	1	1	1	1	1	0	0	18	2
9	1	1*	1*	1	1*	1*	1*	1	1	1	1	1	1*	1	1	1	1	1	0	0	18	2
10	1	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	1	1	1	1	1	0	0	18	2
11	1	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	1	1	1	1	0	0	18	2
12	1	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	1	1	1	0	0	18	2
13	1	1*	1	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	1	1	0	0	18	2
14	1	1*	1*	1*	1*	1*	1*	1	1*	1*	1*	1*	1	1	1	1	1	1	0	0	18	2
15	1	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	0	0	18	2
16	1	1*	1*	1*	1*	1*	1*	1*	1	1*	1*	1*	1*	1*	1	1	1	1	0	0	18	2
17	1	1*	1*	1	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1	0	0	18	2
18	1	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	1	0	0	18	2
19	1	1*	1*	1*	1*	1	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	0	0	18	2
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	19	3
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	4
Dependence Power	20	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	2	1		
Level	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	4		

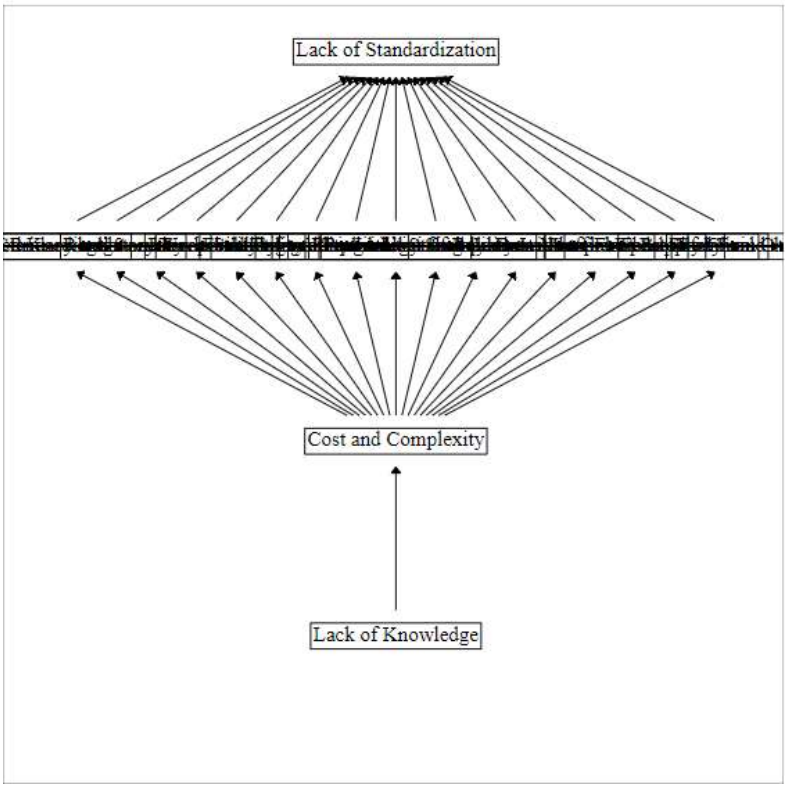
Digraph



Reduced Conical Matrix(CM)

Variables	20	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	2	1	Driving Power	Level
Lack of Standardization	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Lack of Standardization	1	1	1	1	1	1*	1	1	1	1	1	1	1	1	1	1	1	1	0	0	18	2
Data Privacy and Security	1	1*	1	1	1	1	1	1	1	1	1	1*	1	1	1	1	1	1	0	0	18	2
Limited Knowledge and Understanding	1	1*	1*	1	1	1	1	1*	1	1	1	1	1	1	1	1*	1	1	0	0	18	2
Regulatory Environment	1	1*	1*	1*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	18	2
Interoperability	1	1	1*	1*	1*	1	1	1	1	1	1	1	1	1*	1	1	1	1*	0	0	18	2
Scalability	1	1*	1*	1*	1*	1*	1	1	1	1	1	1	1	1	1	1	1	1	0	0	18	2
Food Traceability Issues	1	1*	1*	1	1*	1*	1*	1	1	1	1	1	1*	1	1	1	1	1	0	0	18	2
Traceability of multi-ingredient food products	1	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	1	1	1	1	1	0	0	18	2
Integration with existing systems	1	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	1	1	1	1	0	0	18	2
Technology Scalability Issue	1	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	1	1	1	0	0	18	2
Possibilities of Raw Data Manipulation	1	1*	1	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	1	1	0	0	18	2
Require all Stakeholders within a Food Supply Chain	1	1*	1*	1*	1*	1*	1*	1	1*	1*	1*	1*	1	1	1	1	1	1	0	0	18	2
Laws need to be Updated	1	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	0	0	18	2
Inefficient Process	1	1*	1*	1*	1*	1*	1*	1*	1	1*	1*	1*	1*	1*	1	1	1	1	0	0	18	2
Food Safety	1	1*	1*	1	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1	0	0	18	2
Food Fraud	1	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	1	0	0	18	2
Technical Challenges	1	1*	1*	1*	1*	1	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	0	0	18	2
Cost and Complexity	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	19	3
Lack of Knowledge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	20	4
Dependence Power	20	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	2	1		
Level	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	4		

Final Model*



4. DEMATEL

Decision Making Trial and Evaluation Laboratory (DEMATEL) is a method used to analyze complex systems and identify the key factors that influence the success of a decision or system. It is a multi-criteria decision-making method that helps to identify the interdependencies between factors and their causal relationships.

The DEMATEL method is based on the concept of cause-and-effect relationships, where one factor (the cause) influences another factor (the effect). It is used to identify the key drivers and constraints of a system and to understand how different factors influence each other.

								Scalability													
	0.0	2.7	4.0	3.3	3.0	2.2	2.3	2.7	2.0	2.8	2.8	1.5	2.7	3.0	3.0	2.5	2.5	3.0	2.2	3.2	51.3
	2.0	0.0	2.2	3.3	3.3	2.7	1.3	3.3	2.0	3.0	2.5	2.7	3.0	3.7	2.0	2.5	3.3	2.5	1.0	2.8	49.2
	3.5	3.3	0.0	2.5	3.5	2.2	2.8	3.2	1.7	2.5	2.7	0.8	2.7	3.0	1.5	1.3	2.5	1.8	2.0	2.5	46.0
	1.3	3.8	2.0	0.0	2.7	3.7	3.5	3.2	2.3	3.2	2.7	2.5	2.5	2.5	2.3	1.5	2.8	2.8	4.2	2.3	51.8
	2.2	2.7	1.3	2.2	0.0	1.3	2.5	2.8	3.2	1.2	2.2	2.7	2.8	1.5	3.7	1.8	2.5	2.3	2.8	3.7	45.3
	3.7	1.8	1.3	2.2	2.7	0.0	1.2	1.2	0.8	2.0	3.2	1.8	4.0	3.8	2.5	1.7	2.7	2.8	3.0	2.7	45.0
	3.2	2.3	1.8	2.5	1.2	3.8	0.0	2.5	3.8	1.5	2.8	2.0	1.5	2.5	2.5	3.3	2.3	3.0	2.5	0.7	45.8
	2.7	2.2	1.2	1.3	2.0	3.7	4.0	0.0	1.2	1.2	2.8	1.3	1.2	2.7	1.5	3.7	4.0	2.7	3.3	2.0	44.5
	2.7	3.7	2.0	2.3	2.7	3.7	2.8	2.5	0.0	3.0	2.2	2.5	1.8	1.7	2.7	1.7	3.3	3.2	2.2	1.3	47.8
	2.2	3.8	1.3	2.3	2.7	3.0	1.5	2.3	1.7	0.0	2.8	2.3	2.8	2.2	1.3	2.3	2.5	2.5	2.8	3.3	45.8
	1.7	2.2	2.7	2.5	3.2	1.7	1.8	2.2	2.5	2.8	0.0	2.5	3.7	1.7	2.0	2.7	2.2	2.3	2.3	2.2	44.7
	3.3	2.8	3.5	1.7	2.2	1.5	2.0	2.8	2.5	1.0	3.2	0.0	2.8	2.3	2.8	2.3	3.7	3.5	2.5	3.0	49.5
	2.7	3.7	3.3	3.5	1.8	2.2	3.5	3.3	2.3	2.0	1.8	2.8	0.0	2.3	2.5	2.5	2.8	2.2	2.7	1.7	49.7
	3.0	3.0	2.0	1.8	1.7	3.5	3.7	3.7	3.0	3.3	2.0	2.5	2.8	0.0	1.0	2.7	3.3	2.2	3.0	3.3	51.5
	1.7	1.7	2.5	1.7	2.0	1.8	3.3	3.0	2.2	2.0	1.7	3.7	2.8	1.3	0.0	2.3	2.8	1.5	1.3	3.5	42.8
	2.8	2.5	3.5	2.2	2.8	2.7	1.7	2.5	3.2	3.2	2.5	1.8	2.7	4.7	1.3	0.0	2.2	2.5	2.3	3.5	50.5
	3.2	0.7	3.2	3.3	2.3	2.0	2.3	2.5	1.8	2.5	2.8	1.5	2.8	1.5	3.7	2.2	0.0	3.0	3.3	1.8	46.5
	3.7	2.2	2.8	2.0	3.5	2.2	3.3	3.2	2.7	2.7	2.8	3.2	1.7	1.8	2.0	3.0	2.0	0.0	3.2	1.3	49.2
	1.8	2.0	3.5	2.8	2.3	1.7	3.3	2.7	2.7	1.7	3.7	0.8	2.3	2.7	2.7	1.8	2.2	2.3	0.0	2.3	45.3
	2.5	2.3	2.8	3.8	2.0	2.7	2.5	2.7	3.0	3.2	2.7	4.5	2.3	2.5	1.8	3.3	2.0	2.3	3.8	0.0	52.8
	49.7	49.3	47.0	47.3	47.5	48.0	49.5	52.2	44.5	44.7	49.8	43.5	49.0	47.3	42.8	45.2	51.7	48.5	50.5	47.2	

The process of DEMATEL consists of several steps:

- Identifying the factors that are relevant to the problem at hand.
- Determining the cause-and-effect relationships between the factors.
- Creating a matrix that represents the relationships between factors.
- Analyzing the matrix to identify the key drivers and constraints of the system.
- Prioritizing the factors in order to understand which factors are the most important to address.

	Lack of	Cost and	Lack of	Data Privacy	Limited	Regulatory	Interoperability	Scalability	Food	Traceability	Integration	Technology	Possibilities	Require all	Laws need to	Inefficient	Food Safety	Food Fraud	Technical	Lack of
Lack of Knowledge	0.000	0.050	0.076	0.063	0.057	0.041	0.044	0.050	0.038	0.054	0.054	0.028	0.050	0.057	0.057	0.047	0.047	0.057	0.041	0.060
Cost and Complexity	0.038	0.000	0.041	0.063	0.063	0.050	0.025	0.063	0.038	0.057	0.047	0.050	0.057	0.069	0.038	0.047	0.063	0.047	0.019	0.054
Lack of Standardization	0.066	0.063	0.000	0.047	0.066	0.041	0.054	0.060	0.032	0.047	0.050	0.016	0.050	0.057	0.028	0.025	0.047	0.035	0.038	0.047
Data Privacy and Security	0.025	0.073	0.038	0.000	0.050	0.069	0.066	0.060	0.044	0.060	0.050	0.047	0.047	0.047	0.044	0.028	0.054	0.054	0.079	0.044
Limited Knowledge and Understanding	0.041	0.050	0.025	0.041	0.000	0.025	0.047	0.054	0.060	0.022	0.041	0.050	0.054	0.028	0.069	0.035	0.047	0.044	0.054	0.069
Regulatory Environment	0.069	0.035	0.025	0.041	0.050	0.000	0.022	0.022	0.016	0.038	0.060	0.035	0.076	0.073	0.047	0.032	0.050	0.054	0.057	0.050
Interoperability	0.060	0.044	0.035	0.047	0.022	0.073	0.000	0.047	0.073	0.028	0.054	0.038	0.028	0.047	0.047	0.063	0.044	0.057	0.047	0.013
Scalability	0.050	0.041	0.022	0.025	0.038	0.069	0.076	0.000	0.022	0.022	0.054	0.025	0.022	0.050	0.028	0.069	0.076	0.050	0.063	0.038

Food Traceability Issues	0.050	0.069	0.038	0.044	0.050	0.069	0.054	0.047	0.000	0.057	0.041	0.047	0.035	0.032	0.050	0.052	0.063	0.060	0.041	0.025
Traceability of multi- ingredient food products	0.041	0.073	0.025	0.044	0.050	0.057	0.028	0.044	0.032	0.000	0.054	0.044	0.054	0.041	0.025	0.044	0.047	0.047	0.054	0.063
Integration with existing systems	0.032	0.041	0.050	0.047	0.060	0.032	0.035	0.041	0.047	0.054	0.000	0.047	0.069	0.032	0.038	0.050	0.041	0.044	0.044	0.041
Technology Scalability Issue	0.063	0.054	0.066	0.032	0.041	0.028	0.038	0.054	0.047	0.019	0.060	0.000	0.054	0.044	0.054	0.044	0.069	0.066	0.047	0.057
Possibilities of Raw Data Manipulation	0.050	0.069	0.063	0.066	0.035	0.041	0.066	0.063	0.044	0.038	0.035	0.054	0.000	0.044	0.047	0.047	0.054	0.041	0.050	0.032
Require all Stakeholders within a Food Supply Chain	0.057	0.057	0.038	0.035	0.032	0.066	0.069	0.069	0.057	0.063	0.038	0.047	0.054	0.000	0.019	0.050	0.063	0.041	0.057	0.063
Laws need to be Updated	0.032	0.032	0.047	0.032	0.038	0.035	0.063	0.057	0.041	0.038	0.032	0.069	0.054	0.025	0.000	0.044	0.054	0.028	0.025	0.066
Inefficient Process	0.054	0.047	0.066	0.041	0.054	0.050	0.032	0.047	0.060	0.060	0.047	0.035	0.050	0.088	0.025	0.000	0.041	0.047	0.044	0.066
Food Safety	0.060	0.013	0.060	0.063	0.044	0.038	0.044	0.047	0.035	0.047	0.054	0.028	0.054	0.028	0.069	0.041	0.000	0.057	0.063	0.035
Food Fraud	0.069	0.041	0.054	0.038	0.066	0.041	0.063	0.060	0.050	0.050	0.054	0.060	0.032	0.035	0.038	0.057	0.038	0.000	0.060	0.025
Technical Challenges	0.035	0.038	0.066	0.054	0.044	0.032	0.063	0.050	0.050	0.032	0.069	0.016	0.044	0.050	0.050	0.035	0.041	0.044	0.000	0.044
Lack of Standardization	0.047	0.044	0.054	0.073	0.038	0.050	0.047	0.050	0.057	0.060	0.050	0.085	0.044	0.047	0.035	0.063	0.038	0.044	0.073	0.000

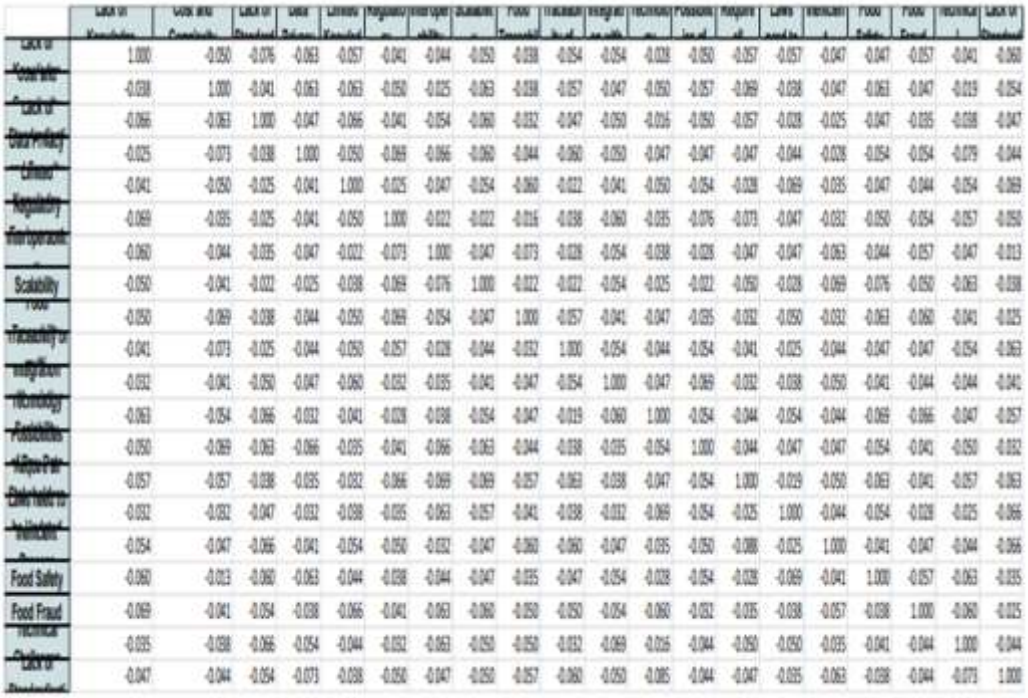
The DEMATEL method is a versatile method that can be adapted to the specific context of the problem and can be used to analyze a wide range of problems such as organizational structures, social systems, and technical systems. The use of DEMATEL can help to understand the complex interactions of the system, identify the key drivers and constraints, and develop strategies to manage or improve the system.

	Lack of	Cost and	Lack of	Data	Limited	Regulato	Interoper	Scalabilit	Food	Traceabil	Integrati	Technolo	Possibilit	Require	Laws	Inefficien	Food	Food	Technica	Lack of
Lack of Knowledge	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost and Complexity	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lack of	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Data Privacy and	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Limited Knowledge	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Regulatory	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Interoperability	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Scalability	0	0	0	0	0	0	0	1	0	0	0	0	0		0	0	0	0	0	0
Food Traceability	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Traceability of multi-	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Integration with	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Technology Scalability	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Possibilities of Raw	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Require all	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Laws need to be	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Inefficient Process	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Food Safety	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Food Fraud	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Technical Challenges	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Lack of	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
									0	0	0	0	0	0	0	0	0	0	0	0

In the context of blockchain technology in food traceability, the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method can be used to identify the key factors that influence the success of a blockchain-based food traceability system. The DEMATEL method can help to analyze the complex relationships between technical feasibility, economic viability, and social acceptability, and how they impact the success of the system.

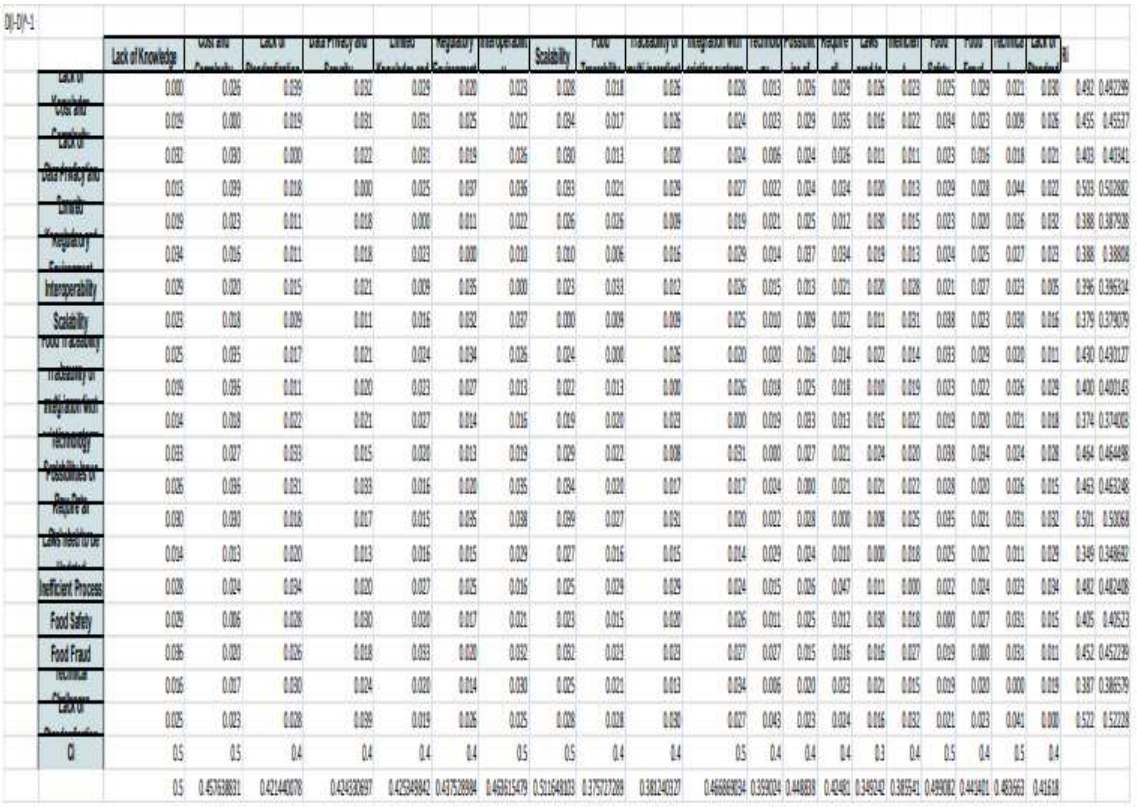
The process of DEMATEL can be used to identify the key drivers and constraints of the system, and to understand how different factors influence each other. For example, the DEMATEL method can be used to identify the key factors that need to be addressed in order to improve the technical feasibility of the system, such as the need for better security measures or the development of more user-friendly interfaces. Similarly, the DEMATEL method can

be used to identify the key factors that need to be addressed in order to improve the economic viability of the system, such as the need for more efficient supply chain processes or the development of more cost-effective solutions.



The DEMATEL approach can also be used to identify the key factors that need to be addressed in order to improve the social acceptability of the system, such as the need for better education and awareness campaigns or the development of more transparent and reliable systems.

	Lack of Knowledge	Cost and Complexity	Lack of Standardization	Data Privacy and Security	Limited Knowledge and Understanding	Regulatory Environment	Interoperability	Scalability	Food Traceability Issues	Traceability of Multi-Ingredient Products	Integration with Existing Technology	Technology Scalability Issues	Possibilities of Raw Data Manipulation	Requirement for Specialized Skills	Laws needs to be Updated	Inefficient Process	Food Safety	Food Fraud	Technical Challenges	Lack of Standardization
Lack of Knowledge	1.474059	0.517179	0.520522	0.514677	0.508849	0.499068	0.517176	0.545498	0.462773	0.479888	0.527614	0.443047	0.515276	0.507052	0.465734	0.479804	0.536747	0.516835	0.523292	0.505539
Cost and Complexity	0.493425	1.451477	0.471609	0.497187	0.496931	0.49076	0.481756	0.538143	0.446289	0.466333	0.503999	0.448189	0.504088	0.501479	0.433574	0.463959	0.534031	0.491941	0.48643	0.483625
Lack of Standardization and Data Privacy and Security	0.488975	0.481627	1.409981	0.455756	0.471604	0.453791	0.478073	0.504278	0.414386	0.430838	0.477451	0.389316	0.468682	0.462086	0.3997	0.417045	0.488311	0.451242	0.472194	0.449012
Limited Knowledge and Understanding	0.500584	0.537055	0.486375	1.456026	0.503348	0.526229	0.53752	0.554222	0.469302	0.484753	0.527417	0.460471	0.513669	0.49975	0.456499	0.464027	0.544511	0.516361	0.558771	0.490901
Regulatory Environment	0.459534	0.462911	0.425238	0.443505	1.40233	0.432351	0.4671	0.492117	0.435755	0.401313	0.4624	0.417861	0.464327	0.428795	0.432756	0.420247	0.482118	0.454003	0.47961	0.462328
Interoperability	0.485089	0.44845	0.42569	0.443718	0.45048	1.405244	0.443065	0.463005	0.39442	0.416508	0.479002	0.402068	0.486332	0.469136	0.411427	0.416115	0.483156	0.461277	0.482771	0.446367
Scalability	0.482051	0.461025	0.436662	0.45129	0.429829	0.4803	1.423871	0.488812	0.449031	0.411903	0.478337	0.406212	0.446384	0.452166	0.414667	0.448157	0.482979	0.469863	0.477154	0.414213
Food Traceability Issues	0.461747	0.443454	0.414159	0.420749	0.431231	0.464832	0.482259	1.430524	0.393499	0.394346	0.466954	0.383646	0.428636	0.443819	0.387324	0.444287	0.497622	0.452046	0.48044	0.425515
Traceability of Multi-Ingredient Products	0.489342	0.499621	0.453803	0.464783	0.471069	0.491977	0.490215	0.506111	1.394896	0.450969	0.4833	0.430096	0.468328	0.451907	0.432801	0.434484	0.517052	0.488448	0.488104	0.441453
Integration with Existing Technology	0.466056	0.489676	0.430427	0.453037	0.457723	0.466772	0.453637	0.489375	0.414288	1.385811	0.480963	0.416501	0.472461	0.448472	0.396723	0.434051	0.488009	0.463067	0.486738	0.463757
Technology Scalability Issues	0.44554	0.450598	0.441998	0.443434	0.454597	0.432124	0.448706	0.47449	0.418417	0.425085	1.417125	0.408287	0.474039	0.427051	0.397936	0.427989	0.469882	0.448051	0.465398	0.431806
Possibilities of Raw Data Manipulation	0.518475	0.502262	0.499215	0.47101	0.479247	0.470512	0.49552	0.531563	0.456988	0.433234	0.51746	1.400488	0.501784	0.479597	0.450205	0.462821	0.540404	0.510356	0.511634	0.486227
Requirement for Specialized Skills	0.507525	0.519076	0.495215	0.502792	0.473673	0.485382	0.522024	0.541083	0.454659	0.450737	0.496015	0.450961	1.451626	0.482284	0.444809	0.466075	0.528221	0.48905	0.515683	0.464205
Laws needs to be Updated	0.531221	0.523801	0.488112	0.491244	0.486435	0.525199	0.54038	0.562982	0.481197	0.489252	0.516665	0.460334	0.519379	1.45662	0.433485	0.485513	0.553756	0.506347	0.539972	0.508464
Inefficient Process	0.430752	0.42439	0.424079	0.413411	0.417388	0.420147	0.458249	0.471348	0.398212	0.39518	0.432096	0.41468	0.442936	0.406054	1.347523	0.408882	0.465171	0.418612	0.43199	0.438679
Food Safety	0.521022	0.510299	0.507131	0.489981	0.500987	0.503615	0.500184	0.537213	0.478482	0.481916	0.517052	0.444097	0.510682	0.531826	0.432008	1.430085	0.526437	0.503993	0.521447	0.507003
Food Fraud	0.484981	0.437197	0.464568	0.470817	0.453627	0.451282	0.472865	0.494517	0.41898	0.431939	0.482595	0.402188	0.473116	0.436823	0.439204	0.432108	1.444012	0.472719	0.497231	0.438893
Technical Challenges	0.5186	0.486938	0.480954	0.470151	0.496948	0.477731	0.51198	0.530675	0.455591	0.455616	0.507346	0.45083	0.476502	0.466979	0.431454	0.469023	0.506484	1.443739	0.517673	0.453537
Lack of Standardization	0.452302	0.450688	0.459266	0.452832	0.443834	0.437604	0.479847	0.48729	0.425323	0.409489	0.486473	0.38247	0.454536	0.447793	0.412263	0.417905	0.473772	0.451549	1.427159	0.437088
	0.533898	0.526354	0.515413	0.536366	0.50506	0.52166	0.533436	0.559757	0.493167	0.49757	0.540791	0.506013	0.523713	0.51335	0.458611	0.506842	0.543931	0.521237	0.566863	1.462285



Ri	Ci	Ri+Ci	Ri-Ci	Column1
0.492299	0.5	0.9546	0.0300	CAUSE
0.45537	0.457639	0.9130	-0.0023	EFFECT
0.40341	0.42144	0.8249	-0.0180	EFFECT
0.502882	0.424331	0.9272	0.0786	CAUSE
0.387928	0.42535	0.8133	-0.0374	EFFECT
0.38808	0.437529	0.8256	-0.0494	EFFECT
0.396314	0.463615	0.8599	-0.0673	EFFECT
0.379079	0.511648	0.8907	-0.1326	EFFECT
0.430127	0.375727	0.8059	0.0544	CAUSE
0.400143	0.38124	0.7814	0.0189	CAUSE
0.374003	0.466869	0.8409	-0.0929	EFFECT
0.464498	0.359024	0.8235	0.1055	CAUSE
0.463248	0.448838	0.9121	0.0144	CAUSE
0.50068	0.42481	0.9255	0.0759	CAUSE
0.348692	0.349242	0.6979	-0.0005	EFFECT
0.482408	0.385541	0.8679	0.0969	CAUSE
0.40523	0.499082	0.9043	-0.0939	EFFECT
0.452239	0.441401	0.8936	0.0108	CAUSE
0.386579	0.483663	0.8702	-0.0971	EFFECT
0.52228	0.41618	0.9385	0.1061	CAUSE

	Lack of Knowledge	Cost and Complexity	Lack of Standardization	Data Privacy and	Limited Knowledge and	Regulatory Environ	Interoperability	Scalability	Food Traceability	Traceability of multi-	Integration with existing	Technology Scalability	Possibilities of Raw	Require all Stakehol	Laws need to be	Inefficient Process	Food Safety	Food Fraud	Technical Challeng	Lack of Standardization
Lack of Knowledge	0	0.026104	0.039409	0.032472	0.028894	0.020467	0.022841	0.027533	0.017518	0.025735	0.028295	0.012579	0.026008	0.028792	0.026445	0.022704	0.025398	0.029347	0.02146	0.0303
Cost and Complexity	0.018679	0	0.01934	0.031368	0.031352	0.02477	0.012158	0.033952	0.016894	0.02648	0.023849	0.022622	0.028623	0.034803	0.016413	0.021954	0.033693	0.023278	0.009207	0.025936
Lack of Standardization	0.032393	0.030387	0	0.021566	0.031242	0.01861	0.025638	0.030225	0.013072	0.020387	0.024098	0.006141	0.023656	0.026238	0.011348	0.010525	0.023106	0.015658	0.017875	0.021247
Data Privacy and Security	0.012633	0.038966	0.018412	0	0.025406	0.036521	0.035609	0.033218	0.020726	0.029055	0.02662	0.021789	0.024306	0.023647	0.020161	0.013174	0.029201	0.027691	0.044067	0.02168
Limited Knowledge and Understanding	0.018845	0.023365	0.010732	0.018188	0	0.010911	0.022103	0.026391	0.026118	0.008862	0.018963	0.021091	0.024901	0.012174	0.030034	0.014583	0.022813	0.020051	0.02572	0.032086
Regulatory Environment	0.033665	0.015561	0.010743	0.018197	0.022737	0	0.009784	0.010224	0.006221	0.015767	0.02871	0.013952	0.03682	0.034038	0.019468	0.013127	0.024386	0.024737	0.027413	0.02253
Interoperability	0.028893	0.020361	0.015152	0.021354	0.009491	0.034848	0	0.02313	0.03258	0.011694	0.025652	0.015377	0.012673	0.021396	0.019621	0.028275	0.02133	0.02668	0.022578	0.005227
Scalability	0.023306	0.018186	0.009145	0.010618	0.016324	0.03226	0.036512	0	0.008689	0.008708	0.025042	0.009682	0.009465	0.022401	0.010997	0.030834	0.037675	0.022816	0.030312	0.016108
Food Traceability Issues	0.024699	0.034674	0.017179	0.020527	0.023776	0.034143	0.026289	0.023948	0	0.025607	0.01982	0.020352	0.016251	0.014256	0.021845	0.013706	0.032622	0.029276	0.020017	0.011141
Traceability of multi-ingredient food products	0.019113	0.035529	0.010863	0.020008	0.023103	0.026504	0.012879	0.021613	0.013069	0	0.025793	0.018394	0.025337	0.018392	0.010012	0.019169	0.023092	0.021912	0.026103	0.029259
Integration with existing systems	0.014055	0.018479	0.022309	0.020983	0.027247	0.013632	0.01557	0.019459	0.019799	0.022796	0	0.01932	0.032899	0.013472	0.015064	0.021602	0.01927	0.019788	0.020554	0.017708
Technology Scalability Issue	0.032711	0.026935	0.033071	0.014858	0.019654	0.013358	0.018758	0.028507	0.021624	0.0082	0.031015	0	0.02691	0.021181	0.024143	0.02044	0.037504	0.033809	0.02421	0.027609
Possibilities of Raw Data Manipulation	0.025616	0.036024	0.031244	0.033308	0.016437	0.019905	0.034582	0.034138	0.02008	0.017063	0.017212	0.024184	0	0.0213	0.021048	0.022054	0.028327	0.020056	0.026028	0.014644
Require all Stakeholders within a Food Supply Chain	0.030164	0.029743	0.018477	0.017046	0.015345	0.034792	0.037503	0.039071	0.027323	0.030868	0.019558	0.021782	0.027853	0	0.008205	0.024505	0.034937	0.020765	0.030661	0.03208
Laws need to be Updated	0.013588	0.013388	0.020067	0.013041	0.0158	0.014579	0.028912	0.026764	0.01633	0.014959	0.013631	0.028779	0.023754	0.010247	0	0.018058	0.024946	0.011885	0.010902	0.029061
Inefficient Process	0.027941	0.024147	0.033595	0.020094	0.026867	0.025419	0.015779	0.02542	0.028679	0.028885	0.024466	0.01541	0.025776	0.046975	0.010902	0	0.021589	0.023848	0.023029	0.033587
Food Safety	0.029068	0.005517	0.027845	0.029705	0.020034	0.017083	0.020884	0.0234	0.014539	0.020439	0.02588	0.011419	0.025372	0.012402	0.030481	0.017721	0	0.026842	0.031371	0.01523
Food Fraud	0.035991	0.019969	0.025792	0.017798	0.032921	0.019591	0.032302	0.031807	0.022995	0.022996	0.027208	0.027021	0.015032	0.016204	0.016333	0.026632	0.019173	0	0.031028	0.011446
Technical Challenges	0.015695	0.017061	0.030425	0.024284	0.019601	0.013805	0.030274	0.024595	0.021467	0.012918	0.033762	0.006033	0.020074	0.022602	0.020808	0.014501	0.019429	0.019942	0	0.019304
Lack of Standardization	0.025263	0.023246	0.02764	0.038916	0.019119	0.02633	0.025241	0.028253	0.028003	0.029823	0.027295	0.043099	0.023129	0.024291	0.015914	0.031977	0.02059	0.02302	0.041129	0

Overall, the use of the DEMATEL method in the context of blockchain technology in food traceability can provide valuable insights into the complex relationships between different elements of the system and can help to identify the key drivers and constraints that need to be addressed in order to improve the overall performance of the blockchain-based food traceability system. The integration of ISM and DEMATEL approach can provide a comprehensive understanding of the system and enable a more effective solution to be developed.

5. Conclusion

Blockchain technology has the potential to improve food traceability by providing a secure and transparent record of all transactions in the food supply chain. An integrated ISM (Information Systems Methodology) and DEMATEL (Decision Making Trial and Evaluation Laboratory) approach can be used to analyze and evaluate the implementation of blockchain in food traceability. This approach can help identify the key factors that influence the success of blockchain implementation, such as technical feasibility, economic viability, and social acceptability. The conclusion is that blockchain can be a valuable tool for improving food traceability, but its success will depend on the specific context and the effectiveness of the implementation strategy.

In conclusion, the use of blockchain technology in food traceability has the potential to provide a secure and transparent record of all transactions in the food supply chain. An integrated ISM and DEMATEL approach can be used to evaluate the implementation of blockchain in food traceability and help identify the key factors that influence its success. It is important to note that the success of blockchain implementation in food traceability will depend on the specific context and the effectiveness of the implementation strategy. However, with the right approach, blockchain technology can play a significant role in improving food traceability and enhancing food safety.

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