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Cognitive Mapping of the Key Factors Influencing Blockchain Adoption in Iran's Food Supply Chains

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Abstract
It is worth mentioning that Blockchain Technology can enhance transparency, trust, and efficiency in a supply chain in general and in food supply chains in particular. Nonetheless, its application in Iran's food industry is still limited due to technological, organizational, strategic and operational challenges. Unlike previous studies, this paper identifies and structures the key factors influencing blockchain implementation in the food sector supply chain through expert confirmation and Interpretive Structural Modeling (ISM). Twenty-six critical drivers were analyzed to reveal their interdependencies and hierarchical significance. The results of this work highlight that developing efficient and effective food supply chain strategies is the most critical factor for successful blockchain adoption, supported by components such as technological readiness, management commitment, transparency, trust, and system quality. The findings also provided a strategic roadmap, which emphasizes aligning technology adoption with organizational preparedness and policy support. This research contributes to the understanding of blockchain diffusion in emerging economies and offers practical and actionable insights for decision-makers seeking to enhance traceability, efficiency, and stakeholder trust in the complex operations of the food supply chain.

Keywords- Food supply chain, Blockchain technology, Interpretive-structural modeling, MICMAC.

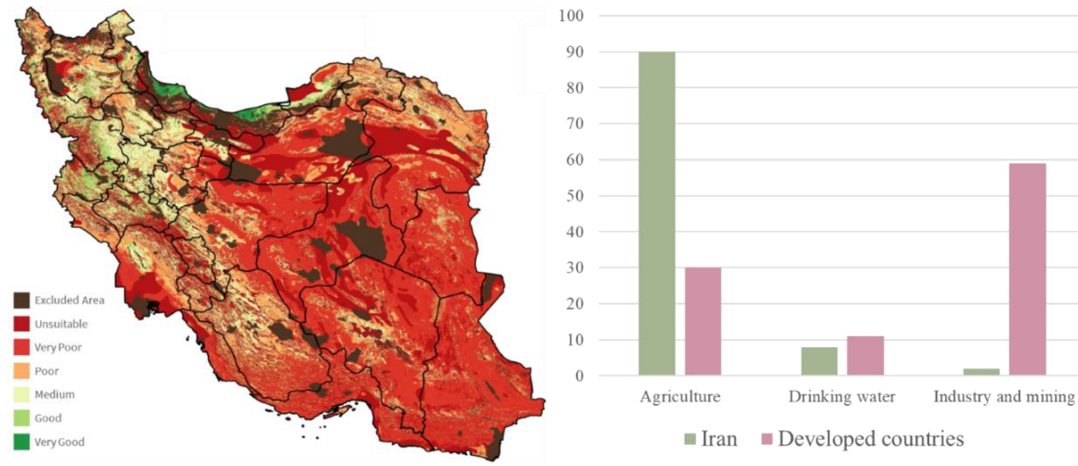
1. Introduction

The global food supply chain is under growing strain in the 21st century (Gölgeci et al., 2023). The rapid expansion of food industries, combined with shifts in dietary habits and lifestyles, has increased consumer awareness of food safety and quality (Hassoun et al., 2024). Today's consumers demand food that is not only safe but also of high quality. Meeting these growing demands for a steadily increasing global population exerts considerable pressure on the food supply chain (Heydari, 2024). This pressure exacerbates issues such as food quality and safety concerns, food waste, price volatility, deforestation, and carbon emissions (Varjani et al., 2024). In addition, critical challenges like product traceability, supply chain transparency, and the adoption of smart agricultural practices add further complexity to food supply chain management (Latino et al., 2022). To remain competitive in today's global competition, supply chain managers must prioritize keeping product value and optimizing efficiency to sustain their competitive comprehensive market position (Negi, 2021).

The agricultural food supply chain encompasses a series of sequential operations, beginning with input supply and production and continuing through post-harvest handling, storage, processing, distribution, marketing, food services, and, ultimately, consumption a process often referred to as "farm to table" (Grewal et al., 2024). Effective supply chain management is vital for creating a competitive advantage, particularly through collaboration in supplier and consumer networks (Nu'man et al., 2020). Organizational interdependence is a key focus, with companies working together to enhance supply chain efficiency (Fontoura & Coelho, 2022). The growing demands of consumers for flexibility, speed, traceability, and information have fueled the rapid development of supply chains in recent years (Razak et al., 2023). This expansion is mainly supported by technological advances that enhance the performance of systems and processes (Dasaklis et al., 2022). In Iran, wheat plays a central role in food security planning, with over 60% of arable land dedicated to its production. Although the country has only about 1% of the world's population, it consumes roughly 2.5% of global wheat output, underscoring wheat's strategic importance in national food policy.

Agriculture is a cornerstone of Iran's food supply chain, with wheat playing a pivotal role in ensuring food security (Karimi et al., 2024). As depicted in the **Figure 1(a)**, much of Iran's agricultural land is categorized as unsuitable or very poor for cultivation due to climatic and geographic constraints. Despite these challenges, over 60% of cultivable lands are dedicated to wheat production, reflecting its strategic importance. However, the inefficient use of resources, particularly water, presents significant issues. As indicated in the accompanying chart, agriculture consumes around 90% of Iran's total water resources, whereas in developed countries the share is closer to 30% (Azadi et al., 2022). This heavy dependence on water-intensive farming accelerates resource depletion and places additional strain on the agricultural supply chain (Cole et al., 2023). These pressures highlight the need to adopt innovative technologies, such as blockchain, to improve resource efficiency and promote sustainable practices across the food supply chain (Rana et al., 2021).

The uneven distribution of water uses in Iran, illustrated in **Figure 1(b)**, underscores the urgency of modernising the supply chain. Only 8% of national water resources are allocated to drinking water and 2% to industry and mining, while agriculture consumes the vast majority, revealing substantial inefficiencies. This pattern contrasts markedly with developed countries, where industry and mining account for 59% of water consumption, indicating a more balanced and efficient allocation (Feng et al., 2023). Such differences point to the need for advanced technologies and improved management systems to optimise Iran's food supply chain (Zahedi et al., 2024). By tackling these inefficiencies and employing blockchain to strengthen traceability and transparency, Iran can foster a more resilient and sustainable food supply chain that is better equipped to meet present and future demand (Rejeb et al., 2024).



(a) (b)

Figure 1. (a) Land suitability for agriculture in Iran (Mesgaran et al., 2017), (b) Water usage distribution in Iran vs. developed countries (Source: Statistical Center of Iran, 2024).

Outside environmental constraints, blockchain adoption in Iran's food industry is also shaped by cultural, regulatory, and economic factors. Culturally, the agricultural sector is dominated by traditional practices and family-owned farms, where trust is built through personal relationships rather than digital systems. Reliance on informal networks often opposes data sharing across the supply chain. From a regulatory standpoint, the lack of unified digital governance frameworks and clear standards for blockchain-based transactions creates uncertainty for both private and public stakeholders. Economically, limited access to investment capital and fluctuating currency values make the initial implementation of advanced technologies financially challenging for small and medium enterprises. Addressing these barriers requires coordinated policy efforts to modernize agricultural regulations, promote financial incentives, and foster digital literacy among supply chain participants.

According to the Food and Agriculture Organization (FAO) of the United Nations, over 80% of Iran's wheat demand is allocated to food production, emphasizing its central role in household nutrition (Hasheminejad et al., 2020). Key ingredients for food products, such as cereal flour, water, leavening agents, and salt, form the foundation of Iran's food supply chain (Hassoun et al., 2024). This supply chain begins with wheat production in fields and ends with food consumption in households. Despite Iran's long-standing history of wheat cultivation and bread production, the overall food quality remains below international standards (Hasheminejad et al., 2020). Addressing this gap necessitates the development of an effective supply chain system capable of delivering food products with adequate quality from production to consumption. Leveraging modern technologies can help supply chains achieve a competitive advantage by enhancing efficiency and reliability (Liu et al., 2023). However, centralized supply chain management systems face risks, including potential failures and vulnerabilities to malicious activities that could manipulate records stored in a central database (Asante et al., 2023).

It is also worth mentioning that BT has clearly occurred as a transformative tool with the potential to address various aforementioned challenges, thus offering a modern and capable solution for improving food supply chain operations (Shoomal et al., 2024). Developed over the past decade, blockchain has grown into a major trend across industries (Hussien et al., 2021). The significant advantages for supply chains include robust data auditing capabilities, enhanced transparency, verifiability, and real-time visibility into the actions of supply chain members (Razak et al., 2023). Blockchain operates as a secure digital record system that prevents data alteration, which securely stores records and data generated within food supply chain management (Rejeb et al., 2021). With its decentralized control, minimal latency, high operational capacity, tamper-proof data storage, and built-in security features, blockchain ensures that once data is recorded, it cannot be altered or manipulated, even by the entity that registered it (Pandey et al., 2022). This tamper resistance allows stakeholders to audit transactions and verify their accuracy. Furthermore, blockchain has become highly prominent in the supply chain and logistics sectors due to its ability to support encrypted transactions, improve transparency, guarantee the immutability of records, and foster trust among stakeholders in the food industry (Rejeb et al., 2022).

For blockchain technology to be effectively implemented in food supply chains, it is first necessary to identify the key drivers and barriers to its adoption and then map out how these factors are interrelated. Despite its considerable promise, blockchain is still relatively immature in many sectors, and there is a lack of structured adoption frameworks within the food industry. In Iran, contextual issues such as water scarcity and fragmented regulation are not merely background conditions; they directly inform several of the Interpretive Structural Modelling (ISM) constructs used in this study. Water-intensive farming practices and disjointed irrigation governance heighten the demand for traceability, transparency, and reliable data across the supply chain, which are reflected in factors such as transparency, system quality, and supply chain traceability. Likewise, regulatory ambiguity and weak digital governance shape organisational readiness, government support mechanisms, and the development of clear operational plans and strategies. These contextual factors therefore operate as upstream drivers that affect the strategic, organisational, and technological readiness dimensions within the ISM framework. Accordingly, the primary aim of this research is to build an ISM-based model that identifies, hierarchically structures, and examines the factors influencing blockchain adoption in the food supply chain sector. In line with this aim, the study addresses the following research questions:

(i) What are the factors to blockchain adoption in Iran's food supply chain, and how can these barriers be effectively addressed?
(ii) What interrelationships exist among these identified factors influencing blockchain adoption in Iran's food supply chain, and how do these relationships affect overall implementation success?

In this paper, the following organization is presented: the main concept of blockchain in the food supply chain is provided in Section 1. The research background is presented in Section 2. Section 3 research method and analysis of the ISM is presented in Section 4. The concluding remarks of the current paper is presented in Section 5.

2. Literature Review

2.1 Blockchain in the Food Supply Chain

A well-performing food supply chain provides the required quantity of food while adhering to safety standards, thus delivering high-quality, accessible, and cost-effective food (Fleming et al., 2021). Various types of technologies have been integrated into the food supply system to mitigate risks, maximize efficiency, and manage complexities. Technologies are primarily used to expedite processes, respond to the growing global demand for food promptly, and trace the origin of food to assess quality and safety aspects (Hassoun et al., 2023). The increased use of technology in the food supply system has contributed to enhancing and maintaining the safety and quality of perishable food items (Abbas et al., 2023). Blockchain has become one of the most popular and disruptive technologies in the supply chain domain (Frizzo-Barker et al., 2020). Blockchain technology offers various advantages and promising prospects. It helps organizations achieve accurate demand predictions, efficiently manage resources, and reduce inventory carrying costs due to its ability to create activity records (Ho et al., 2021). This assists supply chains in reducing risks with lower costs compared to traditional supply chains, where high inventory reserves, excess capacity, and third-party support resources are used to predict disruptions (Ho et al., 2021).

Blockchain leads to increased value for all stakeholders involved in the entire supply chain, including producers, distributors, and consumers (Xue et al., 2021). Compared to other previously developed technologies, blockchain technology has proven to be beneficial and has significant capabilities in improving the food supply chain, such as traceability, transparency, security, efficiency, and cost-effectiveness (Xue et al., 2021). With blockchain, each item in such a system has a digital identity (Sedlmeir et al., 2021), through which digital product information such as origin details, batch numbers, manufacturing and processing data, expiration dates, storage temperatures, and transportation details are digitally linked to food items, and their information is entered into the blockchain at each stage (Vivaldini, 2021). The food supply chain in Iran is one of the most critical food supply chains because food constitutes the main food for the vast majority of the population. Therefore, research on the food supply chain is of paramount importance. According to the FAO report (2012), Iranian families, on average, obtain 47% of their daily calorie intake from the consumption of wheat products and other derivatives. Accordingly, 46.2% and 59.3% of the energy in the dietary pattern of urban and rural residents in Iran is provided by food. Based on this, any policymaking, planning, and action regarding blockchain technology in the food supply chain need to be considered both technically and in terms of social studies.

2.2 Studies Conducted in the Field of Blockchain and Food Supply Chain

Akram et al. (2024) examined the benefits and challenges of blockchain technology for strengthening the food supply chain during COVID-19. Their research aimed to create a more flexible and efficient food supply chain system by providing a roadmap for prioritizing improvements. It is to be noted that the results of this important study emphasized the likely benefits of blockchain, including increased efficiency, transparency, reliability, and traceability in the Iran's food supply chain. Pandey et al. (2022) in their work investigated blockchain technology in the food supply chain using bibliometric analysis. This study also discussed challenges such as scalability, collaboration capabilities, and high costs, proposing potential solutions to the existing problems in blockchain adoption in the food supply chain. The study demonstrated that blockchain is likely to become a dominant technology for increasing transparency and traceability, reducing risks, and most importantly, enhancing trust among various stakeholders in the food supply chain. Kouhizadeh et al. (2021) conducted a study on blockchain technology and sustainable supply chains. In this research, a framework of technology-organization-environment and field force theories was used to examine the barriers to blockchain adoption. The answers of this study show that supply chain and technological challenges are viewed as the most critical barriers by both academic and industry practitioners. Jang et al. (2024) examined resistance to blockchain adoption in the food service sector and found that employee-related characteristics, including traditional behavioural barriers, as well as technology-related factors such as perceived risks, significantly contribute to this resistance. Their study also highlighted the important role of both internal and external stakeholders in weakening the negative impact of blockchain resistance on adoption goals.

Tanwar et al. (2022) explored the opportunities and challenges of blockchain adoption for food safety. The results showed that blockchain technology ensures a high potential for tracking food supply networks with high accuracy. Cozzio et al. (2023) conducted a study on the integration of blockchain technology into the food supply chain. The findings of this research indicated that blockchain enhances consumer trust and increases attitudes and behaviors toward sharing experiences. However, doubts exist regarding the use of this technology due to the increased need for organizational support and concerns about data sharing. Bonetti et al. (2024) investigated the deployment of blockchain for quality food products from a marketing perspective. This study provided a comprehensive review of the marketing impacts of blockchain on various marketing objectives, including product enhancement, brand positioning, consumer relationships, market access, and supply chain relationships. Wamba & Queiroz (2022) observed significant differences in the adoption behavior of blockchain in supply chains between India and the United States. They investigated the challenges of blockchain adoption in supply chains in both countries.

Despite growing global attention to blockchain adoption in supply chain management, prior ISM-based studies in food and agri-food contexts have largely concentrated on generic technological, organizational, and environmental drivers, often producing similar flat or technology-dominant hierarchies across different countries. These studies rarely incorporate country-specific structural conditions or examine how contextual pressures reshape the relative importance and positioning of adoption drivers. In the case of Iran, where agriculture operates under persistent resource constraints and fragmented regulatory arrangements, the structure and dominance of blockchain adoption drivers are expected to differ from those reported in existing food-blockchain and agri-blockchain ISM literature. However, no prior study has systematically compared, reorganized, and hierarchically modeled these drivers within the Iranian food supply chain context. Consequently, the literature lacks an ISM-based framework that reveals how strategic, organizational, technological, and institutional factors interact and are prioritized under such conditions. Addressing this gap allows this study to contribute beyond factor identification by offering a context-specific hierarchical structure of blockchain adoption drivers, thereby extending existing ISM applications and providing novel insights for emerging economies and resource-constrained food systems.

Table 1 presents a comparative overview of the methods, purposes, and study areas of previous research alongside the current study, clearly illustrating the unique contribution of our work and providing a foundation for the present investigation.

Table 1. Related literature on blockchain technology for supply chain management.

Author	**Methods**	**Purpose**	**Area**
Francisco & Swanson (2018)	Squares-Structural Equation Modeling	Adoption of Blockchain for Supply Chain Transparency	FSC
Ghode et al. (2020)	Grey Relational Analysis	Adoption of Blockchain in the Supply Chain	FSC
Choi et al. (2020)	Squares-Structural Equation Modeling	Technology Adoption Barrier	FSC
Kouhizadeh et al. (2021)	DEMATEL	Blockchain For Supporting Sustainability in Supply Chains	FSC
Pandey et al. (2022)	Bibliometric Analysis	Review and Bibliometrics Analysis of the Blockchain in the Food Industry	FSC
Tanwar et al. (2022)	Systematic Survey	Various Problems and Challenges in the Food Industry	Food Industry
Dasaklis et al. (2022)	Systematically Review	Blockchain-Related SC Traceability	FSC
Jang et al. (2024)	Squares-Structural Equation Modeling	Investigate the Effects of Resistance on Blockchain Adoption Intentions	FSC
Cozzio et al. (2023)	Qualitative Method	Consider the Traceability Offered by Blockchain	FSC
Sharma et al. (2023)	Squares-Structural Equation Modeling	Investigate the Drivers of Blockchain Technology Adoption and Their Effect on the Behavioral Intention of Stakeholders	Agri-food supply chain
Mohammed et al. (2023)	Systematically Review	Identify Blockchain Enablers, Benefits and Barriers	Food industry
Waqar et al. (2024)	Interviews with Supply Chain Executives	More Resilient and Efficient Food Supply Chain System	FSC
Bonetti et al. (2024)	Cognitive Mapping Technique	Enrich the Knowledge about Blockchain (BC) Technology Implementation	Agri-food system
Current study	Interpretive Structural Model	Modeling for Effective Factors of Blockchain Technology Adoption	FSC

3. Research Methodology

The current research adopts a descriptive-exploratory approach and utilizes ISM, a methodology that integrates mathematical, statistical, and computational algorithms to analyze complex systems (Ahmad & Qahmash, 2021). ISM enables individuals and groups to systematically define and examine intricate relationships among multiple elements in challenging and multifaceted scenarios (Sarikhani et al., 2020). The detailed steps of the ISM methodology are outlined in **Table 2**.

This research employed a mixed-methods approach, integrating both qualitative and quantitative methodologies. In the qualitative phase, the study population consisted of experts specializing in blockchain applications within the food industry of Gonabad, located in Razavi Khorasan province. Structured, open-ended interviews were purposefully conducted with three experts in this field to identify the key factors influencing blockchain implementation in Gonabad's food industry. After the third interview, data saturation was achieved as no new factors emerged.

Table 2. Steps of the ISM approach.

NO.	Step	Description of the activity performed in the step
1.	Identifying effective factors in blockchain implementation	The study of literature topics and conducting interviews has led to the extraction of 26 components.
2.	Forming the structural self-interaction matrix	Distributing the questionnaire and then entering the data into an interactive matrix format (symbol O for no relationship between i and j, symbol V for one-way relationship from i to j, symbol A for one-way relationship from j to i, and symbol X for two-way relationship between i and j).
3.	Creating the initial receipt matrix	The initial received matrix is transformed from an interactive structural matrix into a binary matrix with zero and one values. In this manner, the number one replaces symbols V and X, while zero is substituted for symbols A and O.
4.	Creating the final received matrix	By applying the relationship count between components, the final received matrix is obtained.
5.	Determination of output and input sets	At this stage, the input and output sets for each of the components are extracted using the final received matrix. The input set for each component consists of the component itself along with other components that contributed to its creation. Similarly, the output set for each component includes the component itself along with other components influenced by this component.
6.	Leveling of components	At this stage, the intersection of the received and preliminary sets is calculated for each component. Components with identical intersections and received sets are considered level 1 components. In the next iteration, level 1 components are removed, and this step is repeated.
7.	Model making	Based on the output of the previous stage, the relationship between components is depicted.
8.	Analysis of penetration power and degree of dependence	At this stage, components are categorized into four autonomous, dependent, linked, and independent groups.

Based on the insights gained from the expert interviews and a systematic literature review, a comprehensive questionnaire was developed to identify the critical drivers of blockchain implementation. It is to be noted that the literature review performed in this paper was steered using major academic databases such as Scopus, Web of Science, and Google Scholar. Search strings combined keywords such as “blockchain adoption,” “food supply chain,” “agri-food,” “drivers,” “barriers,” and “implementation,” and were limited to peer-reviewed journal articles published between 2018 and 2024. The selection of the papers was based on the fact that they were included if papers clearly examined blockchain adoption factors in food or agri-food supply chains, while purely technical papers without adoption-related constructs were excluded from this study. Further, after removing duplicates and screening titles, abstracts, and full texts, a consolidated list of drivers was extracted. These drivers were then refined through three rounds of expert interviews to ensure contextual relevance to Iran’s food industry, resulting in a final set of 26 critical drivers. **Table 3** lists these variables alongside their main reference sources. The final questionnaire was administered to seven industry experts, all of whom held at least a bachelor’s degree and had over 15 years of experience in the food sector. The responses were subsequently analysed using ISM and MICMAC methods (Nazlabadi et al., 2023) to systematically examine the interrelationships, driving power, and dependency structure among the identified drivers.

Table 3. Identified variables of blockchain implementation.

Code	Variable	Source
A	Expected performance	Falwadiya & Dhingra (2022), Orji et al. (2020)
B	Social pressure	Caldarelli et al. (2020)
C	Increase transparency	Akram et al. (2020), Falwadiya & Dhingra (2022), Kamarulzaman et al. (2021)
D	Increase confidence	Malik et al. (2022)
E	Blockchain system quality	Batubara et al. (2018)
F	Technological readiness	Kamarulzaman et al. (2021)
G	Desire for technology	Bauer et al. (2023)
H	Support of senior managers	Kamarulzaman et al. (2021)
I	Organization readiness	Ramdani et al. (2013)
J	Stakeholder support	Cozzio et al. (2023)
K	The existence of a clear and precise operational plan	Experts' opinion
L	Expected benefits	Malik et al. (2022)
M	Develop correct strategies	Experts' opinion
N	Data and transaction security	Falwadiya & Dhingra (2022), Kamarulzaman et al. (2021), Malik et al. (2022)
O	Ability to create comparative advantage	Malik et al. (2022)
P	Formulating a clear path to realize strategies	Experts' opinion
Q	Government support policies	Clohessy et al. (2019)
R	The existence of a collaborative space between the elements of the supply chain	Experts' opinion
S	Preventing corruption	Batubara et al. (2018)
T	Supply chain traceability	Bali et al. (2023), Reddick et al. (2019)
U	Ease of use	Liu et al. (2023)
V	Saving resources and raw materials	Waqar et al. (2024)
W	Reduce and eliminate parallel tasks	Waqar et al. (2024)
X	Prevent material waste	Waqar et al. (2024)
Y	Increasing the health of food	Waqar et al. (2024)
Z	Competitors welcome blockchain implementation	Experts' opinion

4. Results

4.1 Case Study

The case study in this study investigates the integration of blockchain technology in Gonabad's food supply chain, emphasizing wheat and barley production and management. Recent advancements in Gonabad's agricultural infrastructure, including the construction of two 5,000-ton wheat silos, have expanded its total grain storage capacity to 45,000 tons (**Figure 2b**), securing its position as the leading grain storage hub in southern Khorasan Razavi province. The investment of 4.8 million USD, funded through private capital and bank loans, not only modernized the region's storage capabilities but also created direct employment opportunities. Gonabad's agricultural activities include approximately 850 hectares of wheat cultivation annually (**Figure 2a**). The city is implementing blockchain to improve transparency and efficiency across its supply chain, addressing challenges such as flood-related crop losses, supply chain disruptions, and quality control issues.

Blockchain technology aims to bring unprecedented levels of traceability and efficiency to Gonabad's food supply chain, ensuring wheat and barley are tracked seamlessly from farm to silo and onward to the consumer. According to the data, wheat production has shown relative stability over the years, fluctuating between 37,257 tons in 2016 to 22,700 tons in 2023, while barley production witnessed dramatic peaks and declines, notably spiking to 80,870 tons in 2019 before stabilizing at 1,240 tons in 2023. Similarly, rice production decreased from 1,972 tons in 2016 to 185 tons in 2023. These trends underscore the necessity for efficient supply chain practices. Blockchain will enable secure, tamper-proof records to build trust among stakeholders, mitigate inefficiencies, and provide a model for leveraging modern technologies in Iran's broader agricultural sector.

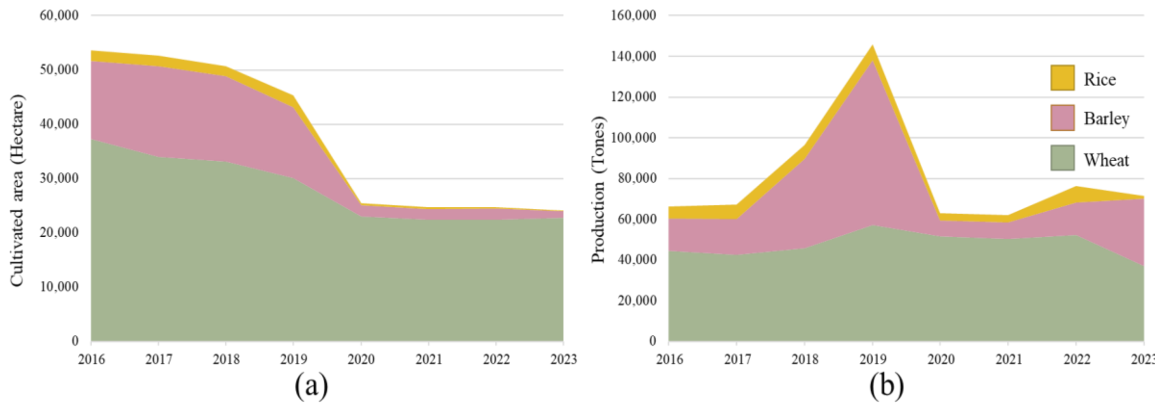


Figure 2. (a) Production trends and (b) cultivated area trends for wheat, barley, and rice in Khorasan Razavi (2016-2023, Source: Statistical Center of Iran, 2024).

4.2 Implementing ISM

In this paper, the data collected were analyzed using the ISM method and MICMAC analysis. The steps and corresponding results are detailed as follows. Upon distributing the questionnaire, expert responses were aggregated using the Mode method in Excel software, enabling the construction of the Structural Self-Interaction Matrix (SSIM). This matrix, which represents the relationships between the identified factors, is presented in **Table 4**.

Table 4. Structural self-interaction matrix.

Item	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A		O	X	X	X	O	O	O	A	V	X	X	O	V	X	A	A	A	X	X	X	X	X	X	X	O
B	O		X	O	O	X	X	X	O	X	O	O	O	O	O	O	V	O	V	V	O	O	V	X	X	V
C	X	X		X	O	O	A	O	O	V	O	X	O	X	V	O	A	O	X	X	X	V	V	V	V	X
D	X	O	X		X	X	X	X	X	X	A	A	O	X	X	O	X	O	X	X	A	V	A	A	A	O
E	X	O	O	X		V	V	X	A	V	O	V	A	X	V	O	O	A	V	V	V	V	X	V	V	A
F	O	X	O	X	A		X	A	X	X	O	V	O	O	V	O	X	X	O	O	O	A	A	O	O	X
G	O	X	V	X	A	X		X	X	X	A	A	O	A	A	A	X	A	A	A	A	X	A	A	A	A
H	O	X	O	X	X	V	X		X	X	A	A	O	A	X	A	A	X	A	A	A	A	A	A	X	A
I	V	O	O	X	V	X	X	X		X	A	A	A	A	V	A	A	X	A	A	A	A	X	A	O	A
J	A	X	A	X	A	X	X	X	X		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
K	X	O	O	V	O	O	V	V	V	V		O	O	O	V	X	X	V	V	V	O	O	O	O	O	O
L	X	O	X	V	A	A	V	V	V	V	O		A	A	X	A	V	X	V	A	A	A	A	A	A	A
M	O	O	O	O	V	O	O	O	V	V	O	V		O	O	O	V	V	O	V	V	V	V	V	O	O
N	A	O	X	X	X	O	V	V	V	V	O	V	O		V	A	X	X	V	O	O	O	O	O	O	X
O	X	O	A	X	A	A	V	X	A	V	A	X	O	A		O	A	X	O	A	A	X	X	X	X	X
P	V	O	O	O	O	O	V	V	V	V	X	V	O	V	O		O	X	O	O	O	O	O	O	O	V
Q	V	A	V	X	O	X	X	V	V	V	X	A	A	X	V	O		X	V	V	V	X	X	X	X	X
R	V	O	O	O	V	X	V	X	X	V	A	X	A	X	X	X	X		X	A	O	X	A	A	V	X
S	X	A	X	X	A	O	V	V	V	V	A	A	O	A	O	O	A	X		A	A	V	V	O	O	O
T	X	A	X	X	A	O	V	V	V	V	A	V	A	O	V	O	A	V	V		V	V	V	V	V	O
U	X	O	X	V	A	O	V	V	V	V	O	V	A	O	V	O	A	O	V	A		V	X	V	V	V
V	X	O	A	A	A	V	X	V	V	V	O	V	A	O	X	O	X	X	A	A	A		A	A	A	X
W	X	A	A	V	X	V	V	V	X	V	O	V	A	O	X	O	X	V	A	A	X	V		V	V	X
X	X	X	A	V	A	O	V	V	V	V	O	V	A	O	X	O	X	V	O	A	A	V	A		V	A
Y	X	X	A	V	A	O	V	X	O	V	O	V	O	O	X	O	X	A	O	A	A	V	A	A		A
Z	O	A	X	O	V	X	V	V	V	V	O	V	O	X	X	A	X	X	O	O	A	X	X	V	V	

After constructing the Structural Self-Interaction Matrix, the SSIM was transformed into the initial reachability matrix by substituting the symbols “V” and “X” with 1, and “A” and “O” with 0 9 (**Table 5**). The SSIM judgements were provided by a panel of seven experts, selected using purposive sampling. The panel considered in this research was consisted of senior managers, supply chain supervisors, and technology specialists from the food industry, each holding at least a bachelor’s degree and possessing more than 15 years of professional experience in agricultural production, food processing, logistics, or supply chain coordination. These experts were chosen based on their direct involvement in decision-making related to adoption of technology and supply chain operations. Further, to enhance judgment reliability, individual SSIM responses were aggregated using the mode method, which is commonly applied in ISM studies to reduce subjectivity and ensure consensus-based structural relationships. Transitivity was then applied to derive the final reachability matrix, meaning that if factor A influences factor B and factor B influences factor C, then factor A is assumed to influence factor C. The initial reachability matrix was iteratively processed until consistency was achieved, and the finalized reachability matrix is reported in **Table 6**. Based on this matrix, the influence power and dependency level of each component were calculated, as presented in **Table 7**. It is to be noted that the dependency level indicates how many components influence a given factor, while influence power represents how many components are affected by that factor, forming the basis for hierarchical ranking and MICMAC classification.

4.3 Leveling of Components

Through the input and output sets of each component, the levels of components are determined. The output set includes the component itself along with the components it can influence, while the input set includes the component itself along with other components that influence it. Once the output and input sets are identified, the intersection of these sets is calculated. Components with identical intersections between their output and input sets are assigned to the first level, representing the most influential components in the model. After identifying the first-level components, they are removed, and the process is repeated iteratively until all components are assigned to their respective levels. According to this table, the components are graded and categorized into four levels, as illustrated in the **Figure 3**. This hierarchical structure provides a clear understanding of the relative importance and influence of each component within the model.

4.4 Structural Model Construction

In the final step of the ISM process, following the grading of components influencing blockchain implementation, a structural model is constructed to represent these components at their respective levels while accounting for their interrelationships. This model visually illustrates the hierarchical and interconnected structure of the components, offering insights into their roles and influence within the system. The structural model of the components effective in blockchain implementation is presented in **Figure 3**.

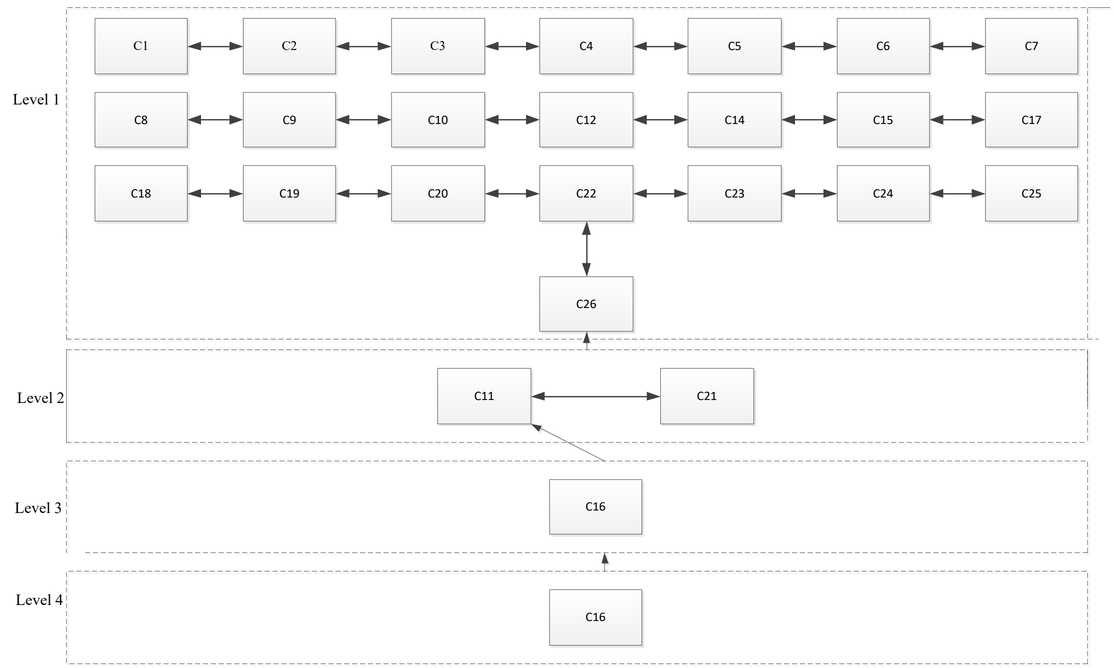


Figure 3. Final levels of blockchain adoption.

4.5 Analysis of Influence Power and Dependency Level

After carefully constructing the structural model of the 26 components influencing blockchain implementation, the analysis focused on evaluating the influence power and dependency levels of these components and translating the dominant strategic driver into actionable options for key actor groups within Iran's food supply chain. Independent variables, led by the capacity to develop effective strategies, exhibit strong influence power with low dependency and therefore shape the direction of adoption across the system. For government actors, this strategic capacity involves creating clear regulatory frameworks for data governance, offering financial incentives or pilot subsidies, and embedding blockchain-related goals into national food security and digital agriculture policies. For agricultural cooperatives, effective strategies involve coordinating data-sharing standards among farmers, pooling resources for shared blockchain platforms, and acting as intermediaries that reduce adoption costs and technical complexity for small producers. For small and medium enterprises in processing, storage, and distribution, strategic options center on phased implementation, beginning with traceability and quality assurance modules, investing in staff training, and aligning blockchain adoption with existing enterprise systems to improve transparency and operational efficiency.

Linking variables, characterized by high influence and high dependency, connect these strategic choices to operational outcomes. Factors such as technological readiness, transparency, trust enhancement, and system quality act as transmission mechanisms through which strategies affect day-to-day practices. Dependent variables reflect performance outcomes that improve once strategic and linking variables are aligned, while autonomous variables play a limited role in shaping adoption pathways. By disaggregating strategy into actor-specific options, this analysis clarifies how the most influential ISM component translates into concrete and differentiated actions across government bodies, cooperatives, and SMEs, strengthening the practical relevance of the proposed blockchain adoption framework.

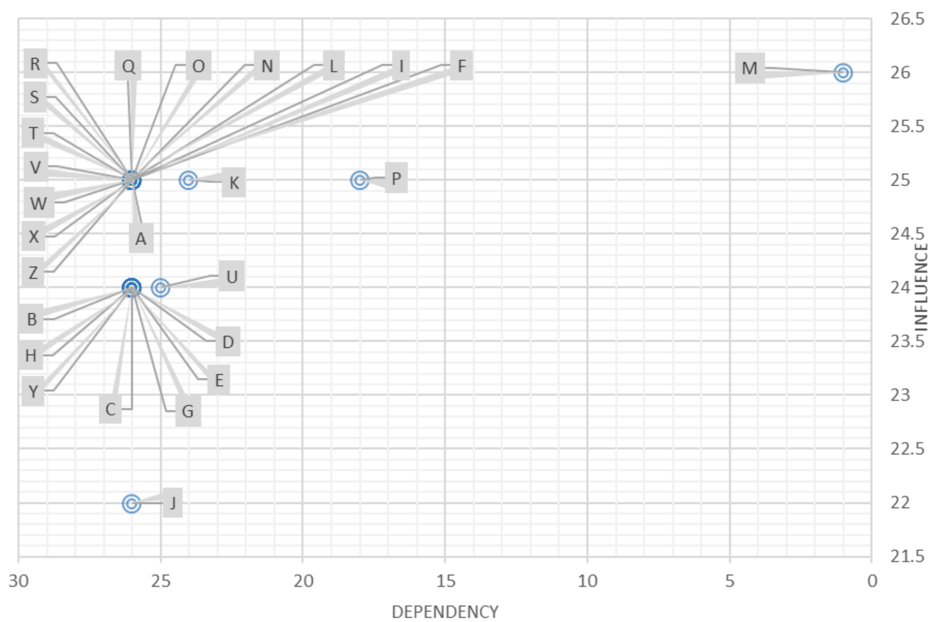


Figure 4. Clustering of indicators.

As evident from **Figure 4**, Component 13 is identified as an independent variable, while the other components are categorized as linking variables according to the analysis. These results are consistent with the findings of the current research in the ISM section.

5. Discussion and Managerial Insights

The present paper aims to identify and analyze the components influencing the implementation of blockchain technology in the food industry using a mixed-methods approach. In the qualitative phase, expert input identified 26 key components, which were further validated through a structured questionnaire. The analysis employed the ISM method to examine the interrelationships among these components and develop a structured model for blockchain adoption. Among the components, "Development of Proper Strategies" emerged as the most influential, demonstrating a pivotal role in facilitating blockchain adoption in the food industry. This component, primarily driven by environmental factors, has a relatively low dependency on other variables, underscoring its central role in influencing the entire system.

The success of blockchain adoption in Iran's food supply chain also depends heavily on the engagement and perspectives of key stakeholders, including farmers, distributors, and consumers. Farmers often face barriers such as limited digital literacy and high initial costs, which affect their readiness to adopt blockchain-based platforms. Distributors and logistics actors emphasize data standardization and interoperability as prerequisites for system integration, while consumers associate blockchain with greater product authenticity and food safety assurance. Understanding these differing priorities is crucial, as stakeholder alignment can accelerate trust formation and improve transparency throughout the supply chain. Hence, policy frameworks and training initiatives should be designed to address each group's specific needs and capabilities, ensuring inclusive adoption across all levels of the food ecosystem.

Key linking components such as Expected Performance, Social Pressure, Increased Transparency, Trust Enhancement, Blockchain System Quality, Technological Readiness, and Senior Management Support play vital roles in shaping blockchain adoption outcomes. These factors interact dynamically, creating both opportunities and challenges for implementation. For example, when senior managers in agro-processing firms in Razavi Khorasan dedicate specific budgets for blockchain trials, they strengthen technological readiness and encourage suppliers to participate in traceability programs. Likewise, food distributors that have adopted blockchain-based QR code systems experience higher transparency and consumer confidence, particularly in monitoring wheat and flour quality. Development of Proper Strategies remains the foundational driver that amplifies the influence of all other components. Organizations that establish phased implementation plans, starting with pilot projects in storage or logistics, tend to achieve smoother transitions and greater stakeholder engagement. Conversely, when strategy formulation is weak, adoption efforts stagnate despite available technology. Components such as Stakeholder Support, though less influential in the ISM hierarchy, become crucial during scaling stages when collaboration among farmers, distributors, and policymakers determines long-term success. Here are some takeaways (TA) and managerial insights (MI) extracted from the findings of the study:

Recognizing these interconnections and learning from emerging implementation cases allows organizations to turn strategic goals into measurable outcomes. This understanding supports the actionable recommendations summarized in **Table 8**, helping managers and policymakers move from conceptual frameworks to practical blockchain integration across Iran's food supply chain.

The survey findings of this study align with and extend existing literature on blockchain adoption in supply chain management. Similar to the results of Kouhizadeh et al. (2021) and Sharma et al. (2023), this research confirms that technological readiness, organizational support, and trust are central to adoption success. However, it contributes uniquely by contextualizing these factors within Iran's food industry, where regulatory constraints, resource inefficiencies, and cultural factors present distinct challenges. Through expert validation and ISM analysis, 26 interrelated components were identified, yielding an integrated view that contrasts with earlier studies that typically examined drivers in isolation. By uncovering the hierarchical influence of strategic, technological, and social factors, this research connects theoretical insights with practical needs, providing a structured framework to support policymakers and managers in developing blockchain adoption strategies tailored to emerging economy contexts.

Table 8. Extracted takeaways and managerial insights.

Code	Key point	Description	Action/Focus
TA1	Development of Proper Strategies	Identified as the cornerstone for blockchain success. Organizations must allocate resources and employ skilled experts to address specific challenges.	Allocate sufficient resources, employ skilled personnel, and create tailored strategies to overcome industry-specific challenges.
TA2	Clear Path Formulation and Operational Plans	"Clear Path Formulation for Strategy Achievement" and operational plans channel strategic influence effectively across other components.	Develop interconnected and well-defined operational plans that align with strategic objectives for broader impact.
TA3	Environmental and Organizational Factors	"Ease of Use," "Technological Readiness," and "Government Support Policies" significantly impact blockchain adoption.	Foster a conducive environment through infrastructure development, regulatory support, and stakeholder collaboration.
MI1	Strategic Leadership	Managers need to lead the crafting and execution of blockchain strategies, focusing on high-impact areas.	Ensure strong leadership in strategy formulation and execution to achieve effective blockchain implementation.
MI2	Investment in Expertise and Technology	Strategic planning necessitates investment in personnel training, suitable blockchain solutions, and collaborative frameworks.	Prioritize funding for technology acquisition, personnel development, and building supply chain collaboration frameworks.
MI3	Policy and Collaboration	Collaboration among governments and industry leaders is essential for creating policies that support blockchain adoption.	Design and implement supportive policies to enhance organizational readiness and build stakeholder trust for smooth blockchain integration.
MI4	Focus on Linking Variables	Components such as "Transparency," "Trust Enhancement," and "Technological Readiness" are critical for bridging strategy and operational success.	Actively measure and improve linking variables to ensure seamless interaction between strategic objectives and operational implementation.

6. Conclusion

This present paper positively identified and analyzed 26 critical components influencing blockchain adoption in the Iran’s food supply chain, with a specific focus on Gonabad's agricultural sector in Iran. Using ISM, the study emphasized the foundational role of "Development of Proper Strategies" as the most influential factor for successful blockchain implementation. This component serves as the cornerstone, enabling transparency, trust, and efficiency across the food supply chain. Additionally, other critical components such as "Clear Path Formulation for Strategy Achievement," "Ease of Use," and "Technological Readiness" were identified, underscoring the interconnected nature of strategic, technological, and organizational factors in driving adoption. The findings highlight blockchain's potential to address key challenges, including inefficiencies, traceability gaps, and resource wastage, making it a transformative tool for sustainable supply chain management.

The structured model developed in this paper provides practical guidance for managers and policymakers by emphasizing the importance of strategic planning, targeted resource allocation, and effective collaboration. By prioritizing these elements, organizations can create conditions conducive to blockchain adoption, thereby enhancing operational performance and reinforcing stakeholder trust. Furthermore, the findings highlight the necessity of aligning technological readiness with clearly defined operational plans to ensure the smooth integration of blockchain solutions into existing supply chain systems.

The Future research in these directions should build on these findings by employing statistical methods to validate the interrelationships among the identified components and quantitatively assess their impacts. Comparative studies across different industries and regions could provide a broader understanding of blockchain adoption, uncovering best practices and industry-specific challenges. Longitudinal studies would also be valuable in evaluating the sustained effects of blockchain on supply chain efficiency, transparency, and trust over time. Furthermore, exploring the integration of blockchain with emerging technologies, such as IoT and AI, could enhance its scalability and effectiveness in supply chain applications. Finally, investigating the influence of government policies and regulatory frameworks on accelerating blockchain adoption, particularly in emerging economies, would yield critical insights for building a supportive ecosystem.

Conflicts of Interest

All the authors declare there is no conflict of interest in the paper.

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AI Disclosure

During the preparation of this work the author(s) used AI for English language editing. After using AI, the author’s reviewed, edited and take full responsibility for the content of the published article.

Appendices

Table 5. Initial access matrix.

Item	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	0	0	1	1	1	0	0	0	0	1	1	1	0	1	1	0	0	0	1	1	1	1	1	1	1	0
B	0	0	1	0	0	1	1	1	0	1	0	0	0	0	0	0	1	0	1	1	0	0	1	1	1	1
C	1	1	0	1	0	0	0	0	0	1	0	1	0	1	1	0	0	0	1	1	1	1	1	1	1	1
D	1	0	1	0	1	1	1	1	1	1	0	0	0	1	1	0	1	0	1	1	0	1	0	0	0	0
E	1	0	0	1	0	1	1	1	0	1	0	1	0	1	1	0	0	0	1	1	1	1	1	1	1	0
F	0	1	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	1
G	0	1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
H	0	1	0	1	1	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0
I	1	0	0	1	1	1	1	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0
J	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K	1	0	0	1	0	0	1	1	1	1	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0
L	1	0	1	1	0	0	1	1	1	1	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0
M	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	1	1	0	1	1	1	1	1	0	0
N	0	0	1	1	1	0	1	1	1	1	0	1	0	0	1	0	1	1	1	0	0	0	0	0	0	1
O	1	0	0	1	0	0	1	1	0	1	0	1	0	0	0	0	0	1	0	0	0	1	1	1	1	1
P	1	0	0	0	0	0	1	1	1	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1
Q	1	0	1	1	0	1	1	1	1	1	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1
R	1	0	0	0	1	1	1	1	1	1	0	1	0	1	1	1	1	0	1	0	0	1	0	0	1	1
S	1	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0
T	1	0	1	1	0	0	1	1	1	1	0	1	0	0	1	0	0	1	1	0	1	1	1	1	1	0
U	1	0	1	1	0	0	1	1	1	1	0	1	0	0	1	0	0	0	1	0	0	1	1	1	1	1
V	1	0	0	0	0	1	1	1	1	1	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	1
W	1	0	0	1	1	1	1	1	1	1	0	1	0	0	1	0	1	1	0	0	1	1	0	1	1	1
X	1	1	0	1	0	0	1	1	1	1	0	1	0	0	1	0	1	1	0	0	0	1	0	0	1	0
Y	1	1	0	1	0	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	1	0	0	0	0
Z	0	0	1	0	1	1	1	1	1	1	0	1	0	1	1	0	1	1	0	0	0	1	1	1	1	0

Table 6. Final received matrix.

Item	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	Influence
A	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
B	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	24
C	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	24
D	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	24
E	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	24
F	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
G	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	24
H	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	24
I	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
J	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	1	1	1	1	0	1	1	1	1	1	22
K	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
L	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	26
N	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
O	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
P	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
Q	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
R	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
S	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
T	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
U	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	24
V	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
W	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
X	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
Y	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	24
Z	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	25
Dependence	26	26	26	26	26	26	26	26	26	26	24	26	1	26	26	18	26	26	26	26	25	26	26	26	26	26	

Table 7. Determining the levels of variables.

Item	Output collection	Input collection	Common collection
A	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
B	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
C	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
D	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
E	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
F	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
G	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
H	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
I	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
J	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
K	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
L	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
M	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	13	13
N	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
O	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
P	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,6,8,9,11,12,14,15,16 17,18,18,19,20,22,23,24,26	1,6,8,9,11,12,14,15,16 17,18,18,19,20,22,23,24,26
Q	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
R	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
S	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
T	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
U	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
V	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
W	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
X	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
Y	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26
Z	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16, 17,18,19,20,21,22,23,24,25,26

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