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Key Success Factors to Implement IoT in the Food Supply Chain

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Abstract

In the Industry 4.0 era, many pioneering industries are leveraging emerging technologies such as the Internet of Things (IoT) as solutions in the digital age. One of the largest and most active industries in Iran is the food industry, which stands to benefit significantly from these advancements. Achieving a sustainable competitive advantage is often possible at the level of the supply chain, where companies use information and communication technologies, such as IoT, to coordinate information, finances, and materials among supply chain actors. This research aimed to identify the key success factors (KSFs) for implementing IoT in the food supply chain. Firstly, through a systematic literature review, the KSFs for IoT implementation in the food supply chain were identified. To develop a measurement model, confirmatory factor analysis using structural equation modeling was employed, making the research applied-descriptive. A questionnaire was designed and completed by 142 members of the "Amadeh Laziz" supply chain (a case study), who were selected using a stratified random sampling method. Confirmatory factor analysis and LISREL 8.83 were then used to validate the proposed model. Finally, the cause-and-effect relationship between KSFs in IoT implementation in the food supply chain was analyzed using Grey DEMATEL. Based on the confirmatory factor analysis findings, the KSFs in implementing IoT in the food supply chain were identified as technical, economic, legal, cultural and social, security, applicability of IoT throughout the supply chain, and implementation of IoT applications. Thus, the measurement model included eight factors and 27 measures. According to the cause-and-effect relationship findings, "Implementation of IoT applications" and "Economic" factors were found to be mostly influenced, while "Applicability of IoT throughout the supply chain" and "Technical" factors were recognized as the most influential. The results of this research can guide food producers and technology policymakers in their supply chains and help avoid trial and error in IoT implementation by leveraging global and national experiences.

Keywords: Internet of Things (IoT), Food Supply Chain, Key Success Factors (KSF), Structural Equation Modeling (SEM), Grey DEMATEL.

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Introduction

Industry 4.0 enhances digitization and automation in manufacturing (Abdirad & Krishnan, 2020), allowing the integration of the entire value chain in production through the formation of a smart network (Yongping et al., 2020). As production is one of the four key processes in the supply chain, Industry 4.0 significantly impacts the supply chain and its management as well (Fatorachian & Kazemi, 2020). The Fourth Industrial Revolution, stemming from digital transformation, enables companies to achieve flexibility and agility in developing supply chain management strategies, thereby creating greater value (Mohaghar et al., 2011; Razavi et al., 2016; Seyedghorban et al., 2019). With the emergence of the Fourth Industrial Revolution, transformative technologies such as IoT have brought significant benefits to industries, offering efficient solutions (Ziatdinov et al., 2024; Adhicandra et al., 2024) that highlight their economic, social, and environmental advantages (Stefanini & Vignali, 2024). Industry 4.0 aims to develop a smart and transparent platform that enables the seamless integration of industrial networks and information to support efficient and effective decision-making (Gallab et al., 2024). These emerging and transformative technologies have intensified competition among companies and government organizations in the countries where they are being developed and implemented (Ghasemi & Mehregan, 2014; Mehregan et al., 2016; Bazargan et al., 2017).

Undoubtedly, Iran's large market, which has remained active even under sanctions, has a significant portion dedicated to the food industry. This industry, which faces low accessibility, needs new technologies more than ever. Although the acceptance of IoT technology in the Iranian food industry is rare, companies that have recognized its advantages have quickly capitalized on it in warehouses, transport fleets, and production lines (Kumar et al., 2024). In particular, the global food supply has recently become a topic of heightened concern, particularly in the wake of the COVID-19 pandemic and the Ukraine conflict, which have significantly exacerbated the issue of food security (Sheykhzadeh et al., 2014).

By connecting the three worlds of cyber, physical, and digital, the IoT has created the ability to connect everything both wirelessly and with wires at any time and in any place (Ghasemi et al., 2016; Zarei et al., 2017; Mohaghar et al., 2021). This capability enables real-time tracing of events, processes, and components throughout the supply chain and creates high predictability for more efficient management (Zarei et al., 2016; Zadtootaghaj et al., 2019; Nasrollahi et al., 2022). As the IoT continues to rapidly develop, businesses are increasingly investing in incorporating it into their processes (Yousefi et al., 2023).

The IoT offers a multitude of advantages for the food industry, revolutionizing the processes of food production, processing, storage, and consumption (Misra et al., 2020). It allows for continuous monitoring of food temperature, humidity, and other environmental conditions, ensuring safe storage and handling of food, thereby minimizing the risk of contamination and spoilage (Yousefi et al., 2019; Nerkar et al., 2023; Abass et al., 2024). Automation and the use of IoT sensors can enhance food production processes such as cooking, processing, and packaging, resulting in higher efficiency, lower labor costs, and better product quality (Sallam et al., 2023; Cammarano et al., 2023).The IoT facilitates continuous, real-time tracking and monitoring of food products as they move through the entire supply chain, starting from the farm and ending at the consumer's table (Kaur, 2021; Goli et al., 2023). This capability ensures that deliveries are made promptly and helps to significantly minimize food waste by maintaining optimal conditions and providing immediate feedback at every stage of the process (Tavana et al., 2023). Sensors in IoT systems can identify equipment failures or malfunctions at an early stage, which helps minimize downtime and maintenance expenses while keeping production lines running smoothly (Shamayleh et al., 2020; Ayvaz et al., 2021). IoT technology allows for constant monitoring of key quality indicators like texture, moisture levels, and pH, guaranteeing that food products consistently meet strict quality standards and are safe for consumption (Kim et al., 2022). Continuous improvement through quality management is essential for achieving and sustaining organizational excellence (Asghari Zade et al., 2011; Safari et al., 2012). Also, Sensors can monitor inventory levels instantly, allowing businesses to manage their stock more efficiently and minimize waste (Mashayekhy et al., 2022; Mahajan et al., 2024; Khan et al., 2024).

With the help of IoT technology, customers can receive instant updates on product availability, prices, and nutritional facts, making it easier for them to make informed purchasing decisions and enjoy a more personalized shopping experience (Ajayi et al., 2023). The massive data produced by IoT can be utilized to examine consumer behavior, preferences, and trends, allowing for data-driven decisions that enhance product development and marketing strategies (Rehman et al., 2023; Kannan et al., 2024). The IoT aids in minimizing food waste through the tracking of expiration dates, monitoring of inventory levels, and anticipation of spoilage (Ramanathan et al., 2023; Onyeaka et al., 2023). Additionally, IoT enables visibility across the supply chain, allowing consumers to monitor where their food products come from and how they are transported (Purnama et al., 2023; Adamashvili et al., 2024). Packaging equipped with IoT technology can oversee the condition of food items throughout their journey and storage, ensuring they reach their destination in optimal quality (Maulana et al., 2021; Fernandez et al., 2023). Moreover, IoT allows businesses to remotely monitor food production facilities, overseeing operations from any location and promptly addressing potential issues (Zhu et al., 2022). Thus, improving quality through IoT leads to enhanced supply chain performance (Mohaghar & Ghasemi, 2011a; Mohaghar & Ghasemi, 2011b; Mohaghar et al., 2011; Jafarnejad et al., 2014).

These advantages are revolutionizing the food industry by increasing effectiveness, minimizing waste, improving quality, and creating fresh avenues for innovation and expansion (Tyagi et al., 2023). While the potential advantages of IoT technology in the food industry are widely recognized, a significant number of its adoption projects fall short of expectations at both the company and supply chain levels (Pérez-Padillo et al., 2022; Ishak et al., 2023). As a result, this study aims to uncover the critical factors that contribute to successful IoT implementation in Iran's food industry, where local business conditions pose unique challenges. However, limited efforts have been made to identify the key success factors (KSFs) of IoT implementation in various industries, with more emphasis placed on its benefits, considerations, and concerns (Nižetić et al., 2020; Chen et al., 2022). Moreover, a comprehensive model that includes the most important KSFs in one place has not been observed in the literature review. Additionally, without understanding how KSFs influence each other, it's impossible to prioritize implementation measures correctly. Neglecting factors that are at the end of the cause-and-effect chain could lead to frustration for project managers overseeing IoT implementations. Thus, clear guidance is crucial, particularly concerning the sequence of these factors.

To achieve these objectives, answering the following questions within the Amadeh Laziz supply chain (one of the largest manufacturers of prepared and semi-prepared foods that has experienced the preliminary implementation of the IoT in its supply chain) was undertaken in this research:

RQ1: What are the key success factors (KSFs) in implementing the IoT in the food supply chain?

RQ2: What is the most effective KSF among the identified factors affecting the implementation of the IoT in the food supply chain?

RQ3: What is the most influential factor among the identified factors affecting the implementation of the IoT in the food supply chain?

RQ4: What is the cause-and-effect relationship between key success factors (KSFs) in implementing the IoT in the food supply chain?

Literature Review

The fourth industrial revolution has enabled significant opportunities to generate value across different industries through the adoption of cutting-edge technologies like the IoT (Malik et al., 2021). The architecture of the IoT consists of various layers, including devices, gateways, networks, platforms, applications, security, and management capabilities (Ghasemi et al., 2016; Pivoto et al., 2021).

The implementation of the IoT in food supply chains is in its early stages compared to its adoption in other manufacturing sectors (Jagtap & Rahimifard, 2019). Nonetheless, the application of IoT has facilitated several aspects of food supply chain management, such as controlling the equipment and devices used for farming and transporting; predicting demand and production; tracking the movement of products and equipment; and monitoring the environment, weather, water management, crops, fertilizer, etc. (Khan et al., 2023). In this research, after reviewing the literature, key success factors (KSFs) in the implementation of the IoT in the food supply chain were identified in a systematic literature review. Subsequently, the factors were categorized into eight distinct categories, including Technical, Economic, Legal, Cultural and Social, Environmental, Security, Applicability of IoT throughout the supply chain, and Implementation of IoT applications.

1. Technical

1.1 Developing Suitable Gateways: Creating a suitable gateway means building communication bridges between IoT devices and central data processing systems. The gateway facilitates the data flow between field devices and backend servers or cloud platforms (Sinha & Dhanalakshmi, 2022). IoT devices often use various communication protocols. Suitable gateways are equipped with the ability to translate and convert data between these protocols and ensure seamless communication and interoperability among diverse sets of devices in the supply chain (Lawal & Nabizadeh Rafsanjani, 2021).

1.2. Developing Suitable Platform: A suitable platform provides a centralized hub for managing and storing data collected from various IoT devices across the supply chain (Narwane et al., 2022). An appropriate platform incorporates advanced analytical tools to process the vast amount of data generated by IoT devices. This enables the extraction of valuable insights, trend analysis, and even predictive capabilities to foresee issues or optimize supply chain processes (Shaygan Mehr et al., 2021).

1.3. Suitable Networking: Real-time data transfer is crucial for decision-making and immediate response. Effective networking ensures that data generated by IoT devices is quickly transmitted to the central system, enabling real-time monitoring and control of the supply chain (Končar et al., 2020).

1.4. Providing Suitable Devices: The selection and deployment of devices specifically designed for recording, transmitting, and receiving data related to various aspects of the supply chain can positively impact the implementation of the IoT in the supply chain. This is because devices with capabilities for adaptation, collaboration, and reliability play a crucial role in creating a connected and intelligent supply chain ecosystem (Wójcicki et al., 2022).

2. Economic

2.1. Funding and Investment: Capital and budget are the main factors in starting any project (Wang et al., 2021). Implementing IoT platforms in industries involves a wide range of sensor and actuator devices and thus requires significant initial investment and initial system maintenance costs (Kamble et al., 2019). Additionally, using IoT technology increases the cost of hardware equipment (Lin et al., 2016). Meanwhile, the lack of economic analysis discourages investors and end-users from adopting IoT applications (Khan et al., 2023).

2.2. Designing a suitable digital business model: In implementing the IoT, an organization needs to upgrade and adopt new business models (Luthra et al., 2018) to manage new smart products and ecosystems. Without adapting current business models, organizations cannot consider the specific features of IoT applications (Birkel & Hartmann, 2019).

2.3. Economic Efficiency: Technology can increase the explicit and tacit knowledge of employees and their technical competences (Momeni et al., 2011a; Momeni et al., 2011b; Rastegar et al., 2012). The IoT in the supply chain facilitates informed decision-making, minimizes errors, and enhances collaboration, leading to more efficient processes, reduced costs, and improved overall economic performance (Ahmetoglu et al., 2022; Zadtootaghaj et al., 2019).

3. Legal

3.1. Data Usage: IoT devices learn about consumers' habits, preferences, and purchasing behaviors through web-related data. However, there are concerns regarding how this data is used. Discriminatory use of data, the use of data for law enforcement purposes, and normative uncertainty are just three examples of challenges that must be addressed through appropriate regulations (Mohammadzadeh et al., 2018).

3.2. Standardization: Standardization is an important factor in the adoption of the IoT (Narwane et al., 2022). The lack of standardization in IoT systems and platforms makes a significant investment in technology difficult for companies. Additionally, the absence of standardization, due to the high diversity of products, leads to a case-by-case implementation approach (Ben-Daya et al., 2020). Standardization is essential for bidirectional communication and information exchange between smart devices, environments, smart objects, and other systems (Sharma et al., 2020). The existence of global standards allows IoT to manage sensitive devices, cloud networks, and end-user platforms (Kamble et al., 2019).

3.3. Regulatory: The emergence of the IoT has generated a wide range of legal and regulatory questions and challenges that require careful examination (Mohammadzadeh et al., 2018). Legal issues are described as the process of introducing new legal enforcement and related interactions (Gamil et al., 2020). When there is a lack of norms and regulatory policies, it leads to insecure standards and incorrect guidelines for actions (Sharma et al., 2020). Due to the lack of a unified and global approach to IoT laws, the challenge of cooperation among stakeholder countries will be exacerbated (Mohammadzadeh et al., 2018).

3.4. Ownership (Intellectual Property): Strong intellectual property (IP) rights facilitate technology transfer and licensing agreements, enhancing collaboration and innovation across the supply chain (Kelly et al., 2020). However, overly restrictive IP practices can hinder interoperability and standardization, limiting the overall effectiveness of IoT solutions in a shared ecosystem. Balancing IP protection with fostering a collaborative environment is crucial for the successful and widespread implementation of IoT in the supply chain (Kumar et al., 2018).

4. Cultural and Social

4.1. Safety (Health) of Employees: IoT devices, such as sensors and wearables, can enhance worker safety by providing real-time data on environmental conditions and potential hazards. This data-driven approach enables proactive measures to mitigate risks, and reduce accident probabilities, and potential injuries (Hawash et al., 2021). Improving safety not only enhances employee well-being but also contributes to increased operational efficiency. Consequently, prioritizing employee safety reinforces a positive work environment and supports the overall success of integrating IoT into the supply chain (Gamil et al., 2019).

4.2. Integrated Training throughout the Supply Chain: Training ensures that all stakeholders, from frontline workers to management, possess the skills to use and understand IoT technologies (Persis et al., 2021). This proficiency is crucial for maximizing the benefits of

IoT, optimizing processes, and troubleshooting issues (Wanasinghe et al., 2020). Training programs also foster a culture of innovation and collaboration, as employees become adept at utilizing IoT tools to enhance efficiency, reduce errors, and improve decision-making (Zahedi & Dehghan, 2019).

4.3. Technology Acceptance: There is still resistance to new and unfamiliar technologies. Public trust and social acceptance are crucial for the successful development of IoT solutions (Janssen et al., 2019). Consumer rejection of IoT technologies can lead to a perceived lower value and, consequently, a lower level of adoption of these technologies (Rejeb et al., 2021).

5. Environmental

5.1. Reducing the Consumption of Fossil Fuels: The IoT technology enables more efficient transportation and logistics operations, leading to optimized routes, reduced idle times, and overall fuel savings (Pourrahmani et al., 2022). Real-time monitoring and data-driven insights provided by IoT devices assist in better fuel management and enable companies to minimize their carbon footprint (Motlagh et al., 2020).

5.2. Tax Laws for Instant Monitoring of Pollutants: Financial incentives such as tax credits provide economic motivation for companies to invest in this technology (Zhao et al., 2020). Additionally, stringent tax laws may steer industries towards more sustainable practices and facilitate the integration of IoT solutions for monitoring and reducing environmental impacts (Haghighi et al., 2016; Tsai & Lu, 2018).

5.3. Creating a Green Image of the Company Brand: Utilizing the IoT for sustainable actions such as efficient energy operations and reducing environmental impacts contributes positively to the company's image (Bafandegan Emroozi et al., 2023). Demonstrating commitment to sustainability through IoT implementation can attract environmentally conscious customers, enhance brand reputation, and potentially lead to increased market share and competitive advantage (Hu et al., 2021; Bafandegan Emroozi et al., 2023).

6. Security

6.1. Service Security: In the field of IoT, the generated data is extensive. This amount of data must be available simultaneously and should not overlap. At the same time, the data must sufficiently authenticate users who may be in other clusters. A security incident, such as damage to the integrity or availability, can affect any IoT protocol or component and create an impact that can be classified as reputational, operational, or legal. Reputational impact refers to damage to the image of the IoT service and consequences such as the loss of trust from IoT users or lack of widespread adoption. (Nozari et al., 2021).

6.2. Network Security: The term network security refers to mechanisms implemented in a network to ensure the reliable operation of the IoT. Security is essential for any network, and since the existing security architecture is designed from a human communication perspective, it may not be suitable for IoT systems. Therefore, developing reliable strategies to ensure the security of IoT networks is of great importance (Mohammadzadeh et al., 2018).

6.3. User Privacy: The security issues are exacerbated by the exponential growth in the number and variety of IoT devices, extending to a global network where every node, sensor, and wireless data transmission becomes a potential target for various attacks (Birkel and Hartmann, 2019). However, numerous solutions exist to mitigate privacy and data security issues at each layer of IoT, such as encryption algorithms, intrusion detection mechanisms, authentication, secure routing protocols, and anonymization techniques. Additionally, newer technologies like blockchain can be employed in IoT to address many privacy and security challenges. In other words, blockchain is logical for IoT platforms where large amounts of confidential data are managed (Henriksen et al., 2020).

7. Applicability of IoT throughout the supply chain

7.1. Preventive Maintenance: Sensors and monitoring devices equipped with the IoT can provide real-time insights into the status of machinery and equipment (Hsu et al., 2023). This data enables predictive analytics and timely identification of potential issues, allowing for preventive maintenance actions to be carried out before equipment failures occur (Zhang et al., 2022).

7.2. Visibility: The IoT technology has enabled real-time tracking and monitoring capabilities, providing unparalleled visibility into the movement of goods, data, and financial transactions. Such enhanced visibility facilitates better decision-making and improved risk management throughout the supply chain (Al-khatib, 2023).

7.3. Replenishment: The IoT facilitates real-time monitoring of inventory levels and enables accurate demand forecasting and timely replenishment (Weißhuhn et al., 2021). Automated systems integrated with the IoT can initiate orders based on actual usage patterns, minimizing the risk of shortages or surplus inventory conditions. This streamlined approach to replenishment enhances the overall efficiency of the supply chain. Additionally, it reduces holding costs and ensures that necessary materials are available exactly when and where they are needed (Mathaba et al., 2017).

8. Implementation of IoT applications

8.1. Warranty for Equipment and Services: Comprehensive warranties instill confidence in the adoption of IoT technologies by mitigating concerns related to equipment reliability and potential defects. These warranties often cover not only physical devices but also associated software and services, ensuring a holistic approach to support. Reliable warranties reduce risk and assure businesses that their investments in IoT are protected, thereby facilitating broader adoption and smoother integration of IoT into the supply chain (Elvy, 2017).

8.2. Managerial Capabilities: Effective leadership and strategic decision-making are essential for maximizing the potential of IoT technologies. Skilled management can align IoT initiatives with organizational goals, allocate resources efficiently, and navigate the complexities of integrating new technologies (Kawai et al., 2018).

8.3. Repairability: Repairability reduces maintenance costs, minimizes electronic waste, and aligns with environmentally conscious methods (Cheng et al., 2023).

8.4. Top Management Support: During the process of adopting the IoT, senior management plays a crucial role in determining the level of adoption, providing necessary resources, and financial support, and developing strategies. However, the adoption of IoT in organizations is a complex task that requires innovation, knowledge, and prior experience of senior management with information and communication technology. It also involves convincing internal stakeholders of the company, such as suppliers, employees, and shareholders (Ahmetoglu, et al., 2022).

Proposed Model and Main Hypothesis

The conceptual model incorporating the research hypotheses is shown in Figure 1.

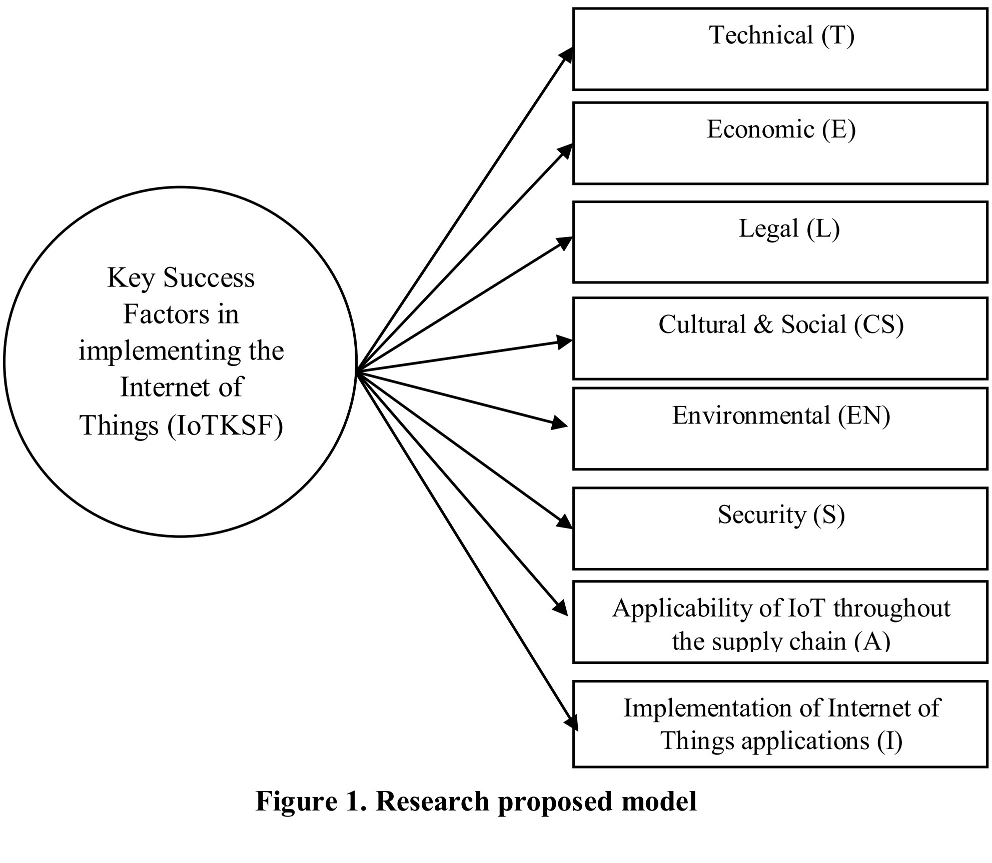

Figure 1. Research proposed model

According to the above-mentioned figure the main hypothesis of this research is:

H1: Key Success Factors in implementing the Internet of Things (IoTKSF) is defined as a higher-order construct that represents Technical (T), Economic (E), Legal (L), Cultural & Social (CS), Security (S), Applicability of IoT throughout the supply chain (A), Implementation of IoT applications (I).

Methodology

The method used in this article is descriptive-correlational and falls under the category of variance-covariance analysis. Figure 2 indicates all the steps undertaken in doing this research.

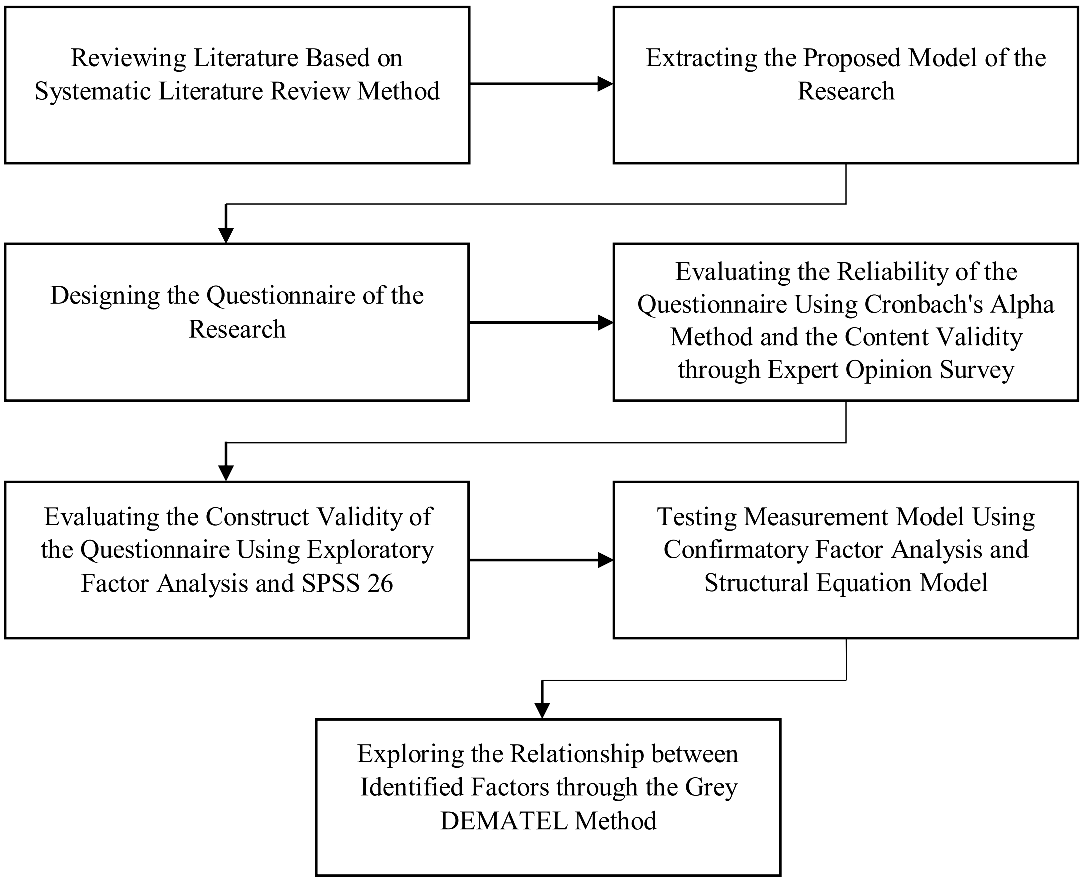

Figure 2. Research steps

For the first step of this research, studies with a focus on the implementation of IoT in the food supply chain were examined eventually 46 of them were selected from a total number of 5378. The databases of these 46 studies are presented in Table 1.

Table 1. Databases of selected research

No	Database
13	Elsevier
1	JMIR Publications
9	MDPI
1	IOP Publishing
6	IEEE
2	Taylor & Francis
4	Emerald
1	ACM Digital Library
1	Inderscience Publishers
4	Springer
1	Washington and Lee University
3	Wiley Online Library

To find the most relevant articles related to the top of current research, papers published between 2016 and 2024 were searched. The search results yielded more than 5,378 research in English. By reviewing the retrieved articles and considering the relevant criteria, inappropriate articles were excluded, and suitable articles were selected. The elimination of inappropriate research was conducted in three stages. In the first stage, articles with titles unrelated to the research topic were discarded. Afterward, the abstracts of remained studies were reviewed. Articles whose abstracts indicated a lack of relevance to the research topic were also discarded. Finally, the content of the remaining articles was studied and analyzed, and high-quality articles were identified, while the rest were omitted. The selection process of articles is shown in Figure 3.

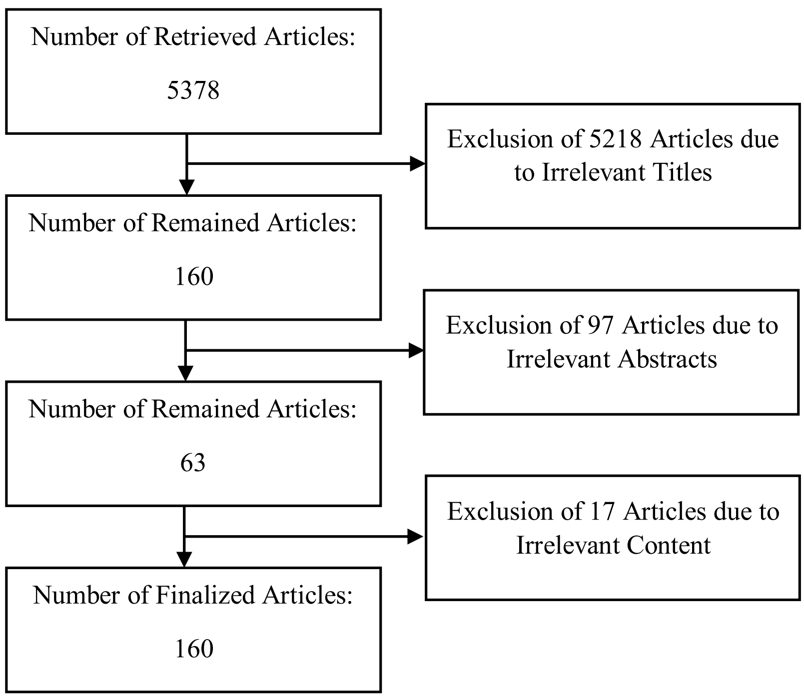

Figure 3. Summary of the article selection process

In this research, KSF in the implementation of IoT in the food supply chain was divided into 8 categories: Technical, Economic, Legal, Cultural and Social, Environmental, Security, Applicability of IoT throughout the supply chain, and Implementation of IoT applications. In Table 2 some of the research which has referred to these factors are mentioned.

Table 2. The identified factors and sub-factors

Factors	Sub-factors	References
Technical (T)	Developing Suitable Gateways (T1)	Cabrini et al. (2021)
	Developing Suitable Platform (T2)	Villa-Henriksen et al. (2020)
	Suitable Networking (T3)	Gupta and Quamara (2020)
	Providing Suitable Devices (T4)	Wójcicki et al. (2022)
Economic (E)	Funding and Investment (E1)	Končar et al. (2020)
	Designing a suitable digital business model (E2)	Birkel and Hartmann (2019)
	Economic Efficiency (E3)	Ahmetoglu et al. (2022)
Legal (L)	Data Usage (L1)	Mohammadzadeh et al. (2018)
	Standardization (L2)	Sharma et al. (2020)
	Regulatory (L3)	Kamble et al. (2019)
	Ownership (L4)	Sigwart et al. (2019)
Cultural & Social (CS)	Safety (Health) of Employees (CS1)	Yuehong et al. (2016)
	Integrated Training throughout the Supply Chain (CS2)	Persis et al. (2021)
	Technology Acceptance (CS3)	Janssen et al. (2019)
Environmental (EN)	Reducing the Consumption of Fossil Fuels (EN1)	Hu et al. (2021)
	Tax Laws for Instant Monitoring of Pollutants (EN2)	Zhang et al. (2022)
	Creating a Green Image of the Company Brand (EN3)	Bafandegan Emroozi et al. (2023)
Security (S)	Service Security (S1)	Nozari et al. (2021)
	Network Security (S2)	Mohammadzadeh et al. (2018)
	User Privacy (S3)	Lawal et al. (2021)
Applicability of IoT throughout the supply chain (A)	Preventive Maintenance (A1)	Hsu et al. (2023)
	Visibility (A2)	Ahmed et al. (2021)
	Replenishment (A3)	Weißhuhn and Hoberg (2021)
Implementation of IoT applications (I)	Warranty for Equipment and Services (I1)	Elvy (2017)
	Managerial Capabilities (I2)	Kawai et al. (2018)
	Repairability (I3)	Cheng et al. (2023)
	Top Management Support (I4)	Singh et al. (2023)

Information Gathering Tools

Data needed for undertaking this research was gathered through a questionnaire. The formulated questionnaire was composed of two parts: the first part contained 2 demographic questions regarding the place of service and service record of respondents. The second part includes 27 questions, asking for the extent of effectiveness of each identified measure, using a 5-point Likert Scale.

Validity and Reliability of the Questionnaire

To examine the content validity of the questionnaire, it was presented to the expert team. The expert team initially contained 3 members with at least 5 years of experience in the field of IoT implementation in the food supply chain, and developed into a twelve-member team after executing the snowball sampling technique. According to the experts' perspectives, the content validity of the questionnaire was confirmed due to the comprehensiveness of the identified factors and sub-factors. In this research, the Cronbach's alpha method was employed to assess the reliability of the questionnaire. The calculated Cronbach's alpha for the questionnaire used in the study was equivalent to 0.729. Since this figure exceeded 70%, the reliability of the questionnaire was confirmed.

Statistical Population and Sample Size

This research examines the research questions at the supply chain level of the Amadeh Laziz Company, comprising 5 upstream companies (including Ard Alborz Company, Ard Markazi Company, Kaveh Selolez Zarin Company, Zhivadan Company, and International Flavors & Fragrances Inc.), the mainstream company (Amadeh Laziz), and one downstream company (Pakhsh Alpa Company). The statistical population of this study consisted of CEOs, executive managers, logistics experts, operational managers, information technology managers, and communication technology experts with a minimum of 5 years of experience who were employed in the supply chain of Amadeh Laziz Company. Using the Morgan Table Method, a sample size of 142 was recommended for the statistical population of this study. Table 3 gives detailed information about the population and sample size of each of the seven companies in the supply chain of Amadeh Laziz Co.

Table 3. The population and sample size in each of echelons

Companies	Ard Alborz	Ard Markazi	Kaveh Selolez Zarin	Zhivadan	International Flavors & Fragrances Inc.	Amadeh Laziz	Pakhsh Alpa	Total
Position in the supply chain	Up Stream	Up Stream	Up Stream	Up Stream	Up Stream	Main Stream	Down Stream	-
Population size	33	27	22	28	23	42	26	201
Population percentage	%16.4	%13.4	%11	%14	%11.4	%20.9	%12.9	%100
Sample size	23	17	17	20	17	30	18	142
Sample percentage	%16.2	%12	%12	%14.1	%12	%21.1	%12.6	%100

Also, the judgmental sampling method was used to complete the second questionnaire (using Grey DEMATEL method) and the questionnaire was distributed and completed among 5 senior managers involved in the implementation of the IoT in the supply chain of Amadeh Laziz.

Structural Equation Modeling (SEM)

SEM is a comprehensive statistical approach to test hypotheses about relations among observed and latent variables. A major advantage of SEM is the ability to estimate a complete model incorporating both measurement and structural considerations. In this research the measurement model was tested by applying the structural equation modeling (SEM) method, using the software program LISREL 8.83. The seven fit indices used in this research and values indicating acceptable model fit include:

1. The ratio of the χ^2 statistic to its degrees of freedom, with values of less than 3 indicating acceptable fit;
2. Root mean squared error of approximation (RMSEA), with values below 0.08 representing acceptable fit;
3. Goodness of fit index (GFI), with values exceeding 0.9 indicating good fit;
4. Adjusted GFI (AGFI), with values exceeding 0.8 indicating acceptable fit (Ngai et al., 2007).

Grey DEMATEL

The Grey DEMATEL method has been utilized to examine the impact of factors on one another. Hence, a questionnaire containing a matrix of direct relationship dimensions of the designed model was distributed among the above-mentioned senior managers. Finally, five completed questionnaires were collected. The subsequent steps of this research phase were as follows.

Step 1: Generating the grey direct-relation matrix

- No influence (0,0),
- Very low influence (0,0.25),
- Low influence (0.25,0.5),
- High influence (0.5,0.75),
- Very high influence (0.75,1)

Step 2: Normalizing the grey direct-relation matrix

$$\underline{\otimes}\tilde{x}_{ij}^{p} = (\underline{\otimes}x_{ij}^{p} - min\underline{\otimes}x_{ij}^{p}) \,/\, \Delta_{min}^{max} \quad (1)$$

$$\overline{\otimes}\tilde{x}_{ij}^{p} = (\overline{\otimes}x_{ij}^{p} - min\overline{\otimes}x_{ij}^{p}) \,/\, \Delta_{min}^{max} \quad (2)$$

$$\Delta_{min}^{max} = max\overline{\otimes}x_{ij}^{p} - min\underline{\otimes}x_{ij}^{p} \quad (3)$$

Step 3: Converting fuzzy data into crisp Scores

$$Y_{ij}^{p} = \frac{\left(\underline{\otimes}\tilde{x}_{ij}^{p}(1-\underline{\otimes}\tilde{x}_{ij}^{p})+(\overline{\otimes}\tilde{x}_{ij}^{p}\times\overline{\otimes}\tilde{x}_{ij}^{p})\right)}{\left(1-\underline{\otimes}\tilde{x}_{ij}^{p}+\overline{\otimes}\tilde{x}_{ij}^{p}\right)} \quad (4)$$

$$Z_{ij}^{p} = min\underline{\otimes}x_{ij}^{p} \; / \; Y_{ij}^{p}\Delta_{min}^{max} \quad (5)$$

Step 4: Generating the direct influence matrix combining experts' scores (by same weight).

$$Z_{IJ} = \frac{1}{p}(Z_{IJ}^{1} + Z_{IJ}^{2} + \cdots + Z_{IJ}^{p}) \quad (6)$$

Step 5: Normalizing the initial influence matrix that is presented.

$$N = s \cdot Z \quad (7)$$

$$s = \frac{1}{max\sum_{j=1}^{n} z_{ij}} \quad (8)$$

Step 6: Constructing the total influence matrix T

$$T = N + N^{2} + N^{3} + \cdots = \sum_{i=1}^{\infty} N^{i} = N(1-N)^{-1} \quad (9)$$

Step 7: Producing the influential relation map

$$P_i = \{R_i + D_j | i = j\} \quad (10)$$

$$E_i = \{R_i - D_j | i = j\} \quad (11)$$

$$R_i = \sum_{j=1}^{n} t_{ij} \quad \forall_i \quad (12)$$

$$D_j = \sum_{i=1}^{n} t_{ij} \quad \forall_j \quad (13)$$

Results

The data collected from questionnaires was analyzed using exploratory factor analysis (for construct validity) and confirmatory factor analysis (SEM) techniques (for explaining the measurement model). For conducting exploratory factor analysis, the SPSS 26 was utilized, and for confirmatory factor analysis (SEM), the LISREL 8.83 was employed. In the subsequent phase of the study, to understand the relationships among the identified factors and determine the most influential and affected ones, the Grey DEMATEL method was applied. The results of all the above-mentioned methods are presented in the following.

The Results of Exploratory Factor Analysis

After conducting exploratory factor analysis on the initial questionnaire with 27 variables, the Kaiser-Meyer-Olkin (KMO) test yielded a value of 0.775, as indicated in Table 4, which is greater than 0.6, demonstrating the adequacy of the sample size. Additionally, Bartlett's test of sphericity resulted in a value of 0.000, less than 5%, indicating the construct validity of the questionnaire.

Table 4. Rotated matrix of components

Questions	Component							
	Implementation of IoT applications (I)	Technical (T)	Legal (L)	Applicability of IoT throughout the supply chain (A)	Environmental (EN)	Security (S)	Cultural & Social (CS)	Economic (E)
T1	.071	**.940**	-.001	.033	-.079	-.033	.060	.100
T2	.100	**.900**	.125	.086	.164	.112	.051	.104
T3	.003	**.898**	.043	.088	-.094	-.003	.141	.054
T4	.097	**.905**	.091	.073	.130	.012	.029	.126
E1	-.079	.195	-.004	.069	-.019	-.002	.070	**.899**
E2	.169	.028	.346	-.017	.233	.251	-.120	**.678**
E3	-.016	.138	.074	.170	.149	.081	.046	**.874**
L1	.197	.088	**.828**	.211	.045	.231	.021	.062
L2	.266	.029	**.840**	.107	.167	.169	.086	.079
L3	.212	.000	**.801**	.106	.166	.358	-.040	.063
L4	.055	.163	**.828**	.156	.017	.101	-.054	.097
CS1	.161	-.011	.115	.114	.213	.293	**.735**	-.025
CS2	.064	.092	-.030	.070	.131	-.041	**.921**	.056
CS3	.016	.190	-.069	.211	.027	-.106	**.888**	.009
EN1	.132	-.040	.181	.104	**.897**	.042	.130	.103
EN2	.164	.000	.162	-.018	**.922**	.126	.106	.016
EN3	.077	.132	-.022	.070	**.841**	.166	.110	.157
S1	.211	.017	.248	.111	.166	**.838**	.095	.093
S2	.213	-.068	.463	.075	.128	**.782**	.028	.023
S3	.116	.114	.219	.233	.098	**.809**	-.038	.149
A1	.067	.123	.147	**.923**	.054	.092	.100	.077
A2	.102	.100	.163	**.918**	.027	.139	.110	.081
A3	.136	.044	.181	**.862**	.076	.129	.184	.086
I1	**.909**	.026	.197	.037	.116	.174	.040	-.022
I2	**.819**	.160	.155	.161	.085	.007	.001	-.043
I3	**.885**	.045	.160	.057	.127	.144	.119	.041
I4	**.915**	.048	.118	.068	.077	.164	.081	.035

As can be seen in Table 4, the items of the first questionnaire collectively form 8 factors, and the total variance explained was measured at 71.85%. This signifies the structural validity of the questions in this domain. Moreover, the rotated matrix of components (Table 4) specifies the association of each item with its corresponding factor, corroborating the accuracy of the categorization of factors into 8 distinct groups.

The Results of Confirmatory Factor Analysis

In this research, confirmatory factor analysis has been employed to examine the relationships between latent and observed variables. Based on the results of t-value statistics (using LISREL 8.83), which are shown in Figure 1, evaluation indicators of each of the scales at the level of 5% of the t-value were larger than 1.96. Therefore, the research hypothesis is confirmed and supported. The ratio of chi-square to degrees of freedom is 1278.2 (less than the allowable value of 3), and the average of squared errors is 0.063 (less than the allowable value of 1.0). Therefore, there is not much need for modifications. The P-value is also less than 0.05. The desired value for the Goodness of Fit Index (GFI) in this model is 0.95 (above 0.90), and the Adjusted Goodness of Fit Index (AGFI) for this model is 0.87 (above 0.80).

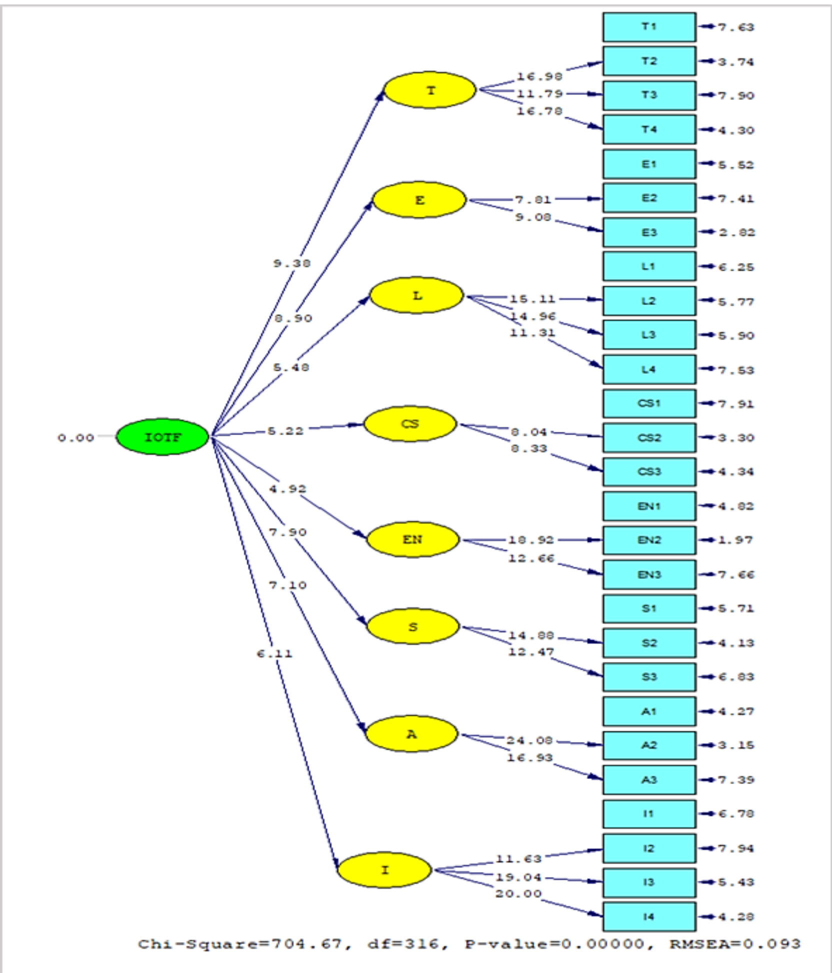

Figure 4. (t-value) to confirmatory factor analysis (CFA)

The Results of Grey DEMATEL

After the completion of 5 questionnaires by senior supply chain managers of Amadeh Laziz Company, the direct influence matrix was formed as shown in Table 5.

Table 5. The direct influence Matrix

Matrix Z	T	E	L	CS	EN	S	A	I
Technical (T)	0	0.75	0.35	0.35	0.71	0.89	0.89	1.175
Economic (E)	0.89	0	0.08	0.17	0.35	0.71	0.89	1.175
Legal (L)	0.65	0.4375	0	0.41	0.41	0.71	0.47	0.95
Cultural & Social (CS)	0	0.6875	0.41	0	0.65	0.71	0.65	1.175
Environmental (EN)	0.17	0.4375	0.41	0.95	0	0.11	0.11	0.5
Security (S)	0.59	0.9375	0.17	0.35	0.11	0	0.29	0.95
Applicability of IoT throughout the supply chain (A)	0.65	0.9375	0.71	0.89	0.71	0.65	0	0.95
Implementation of IoT applications (I)	0.47	0.75	0.17	0.65	0.65	0.65	0.71	0

Then, the initial influence matrix was normalized which is presented in Table 6.

Table 6. Normalized influence matrix

Matrix N	T	E	L	CS	EN	S	A	I
Technical (T)	0	0.1091	0.0509	0.0509	0.1033	0.1295	0.1295	0.1709
Economic (E)	0.1295	0	0.0116	0.0247	0.0509	0.1033	0.1295	0.1709
Legal (L)	0.0945	0.0636	0	0.0596	0.0596	0.1033	0.0684	0.1382
Cultural & Social (CS)	0.0000	0.1000	0.0596	0	0.0945	0.1033	0.0945	0.1709
Environmental (EN)	0.0247	0.0636	0.0596	0.1382	0	0.0160	0.0160	0.0727
Security (S)	0.0858	0.1364	0.0247	0.0509	0.0160	0	0.0422	0.1382
Applicability of IoT throughout the supply chain (A)	0.0945	0.1364	0.1033	0.1295	0.1033	0.0945	0	0.1382
Implementation of IoT applications (I)	0.0684	0.1091	0.0247	0.0945	0.0945	0.0945	0.1033	0

In the next step, the total influence matrix T as indicated in Table 7 was constructed.

Table 7. The total influence matrix

Matrix T	T	E	L	CS	EN	S	A	I
Technical (T)	0.1278	0.2784	0.1284	0.1866	0.2234	0.2716	0.2627	0.3800
Economic (E)	0.2295	0.1592	0.0837	0.1452	0.1641	0.2324	0.2480	0.3521
Legal (L)	0.1883	0.2038	0.0633	0.1644	0.1605	0.2213	0.1829	0.3096
Cultural & Social (CS)	0.1089	0.2389	0.1216	0.1155	0.1931	0.2213	0.2063	0.3400
Environmental (EN)	0.0870	0.1524	0.0994	0.1985	0.0716	0.1025	0.0981	0.1942
Security (S)	0.1716	0.2482	0.0766	0.1380	0.1087	0.1133	0.1511	0.2886
Applicability of IoT throughout the supply chain (A)	0.2194	0.3091	0.1792	0.2596	0.2324	0.2540	0.1580	0.3715
Implementation of IoT applications (I)	0.1642	0.2429	0.0908	0.1967	0.1910	0.2115	0.2122	0.1882

Afterward, the influential relation map was developed which can be seen in Table 8.

Table 8. Superiority degrees and net effect values for each factor

Dimensions	Ri[1]	Dj[2]	Pi[3]	Ei[4]
Technical (T)	**1.8590**	1.2968	3.1557	0.5622
Economic (E)	1.6142	**1.8329**	**3.4472**	-0.2187
Legal (L)	1.4941	0.8430	2.3371	**0.6512**
Cultural & Social (CS)	1.5456	1.4045	2.9502	0.1411
Environmental (EN)	1.0037	1.3446	2.3483	-0.3410
Security (S)	1.2961	1.6280	2.9241	-0.3319
Applicability of IoT throughout the supply chain (A)	**1.9830**	1.5194	**3.5024**	0.4637
Implementation of IoT applications (I)	1.4976	**2.4241**	**3.9217**	-0.9265

Additionally, a cause-effect diagram can be defined for each indicator, utilizing the total influence matrix. To complete this stage, the threshold value (ϴ) was clarified in a way that the number of selected relationships through the relationship ϴ <tij would be such that it facilitates the creation of a simpler and more understandable graphical representation. Here, an attempt has been made to determine a suitable value for ϴ using the average plus half of the variance (according to experts' opinions), which is equal to 0.2297. The selected relationships (greater than 0.2297) can be observed in Table 9.

Table 9. The total influence matrix and selected relationships

Matrix T	T	E	L	CS	EN	S	A	I
Technical (T)	0.1278	**0.2784**	0.1284	0.1866	0.2234	**0.2716**	**0.2627**	**0.3800**
Economic (E)	0.2295	0.1592	0.0837	0.1452	0.1641	**0.2324**	**0.2480**	**0.3521**
Legal (L)	0.1883	0.2038	0.0633	0.1644	0.1605	0.2213	0.1829	**0.3096**
Cultural & Social (CS)	0.1089	**0.2389**	0.1216	0.1155	0.1931	0.2213	0.2063	**0.3400**
Environmental (EN)	0.0870	0.1524	0.0994	0.1985	0.0716	0.1025	0.0981	0.1942
Security (S)	0.1716	**0.2482**	0.0766	0.1380	0.1087	0.1133	0.1511	**0.2886**
Applicability of IoT throughout the supply chain (A)	0.2194	**0.3091**	0.1792	**0.2596**	**0.2324**	**0.2540**	0.1580	**0.3715**
Implementation of IoT applications (I)	0.1642	**0.2429**	0.0908	0.1967	0.1910	0.2115	0.2122	0.1882

As evident from Table 9, eighteen relationships are greater than the value of ϴ, and in the cause-effect diagram, only these relationships are depicted. It should be noted that determining the magnitude of ϴ only affects the number of graphs, and the higher it is, the simpler the diagram becomes, but it represents fewer meaningful relationships. The determination of this value has been made through the consensus of experts. Here, the i dimension that has an impact on the j dimension is represented by a direct arrow. The diagram can be observed in Figure 5.

1 . Sum of Causes
2 . Sum of Effects
3 . The overall importance of the index
4 .Net Effect

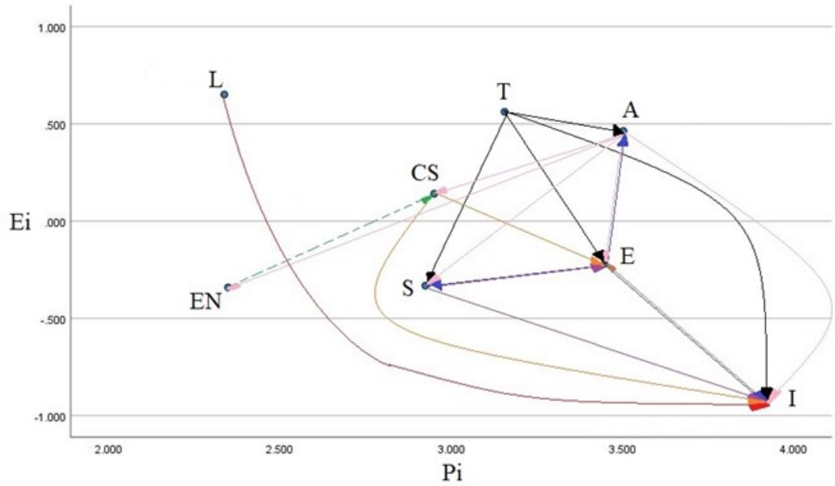

Figure 5. The cause-effect diagram

Discussion and Conclusion

High levels of technological readiness are associated with increased innovation in countries (Jafarnejad et al., 2010; Jafarnejad et al., 2011; Razavi et al., 2011; Razavi et al., 2012; Ghasemi et al., 2013; Jafarnejad et al., 2013), and it is necessary to transition from a factor-driven economy to an efficiency-driven and innovation-driven economy (Vares et al., 2011; Vares et al., 2012; Razavi et al., 2015). The food chain is increasingly concerned due to the war in Ukraine, food shortages, droughts, natural disasters, and population growth (Sadeghi Moghadam et al., 2017; Ghasemi et al., 2018; Karimi et al., 2022). Internet of Things (IoT) technology, one of the transformative technologies of the fourth industrial revolution, has played a significant role in increasing production and improving supply chain processes in various industries, including the food industry (Mohaghar et al., 2021; Mohaghar et al., 2023). This technology has played an important role in the formation of a new generation of intelligent supply chains (Hoorshad et al., 2023). The IoT contributes to the sustainability of the supply chain while simultaneously achieving economic, social, and environmental goals (Zarei et al., 2017; Jamalian et al., 2018).

The objective of the current research was to identify the factors influencing the implementation of IoT in the food supply chain and determine the relationships among these factors. After a systematic literature review, 27 key success factors for implementing IoT were identified, including: developing suitable gateways (Sinha & Dhannalakshmi, 2022), deploying suitable platforms (Ghasemi et al., 2016), ensuring suitable networking (Končar et al., 2020), providing suitable devices (Pivoto et al., 2021), securing funding and investment, designing a suitable digital business model, ensuring economic efficiency, data usage, standardization, regulatory compliance, ownership (intellectual property), safety (health) of employees, integrated training throughout the supply chain, technology acceptance, reducing the consumption of fossil fuels, tax laws for instant monitoring of pollutants (air, water, sound, etc.), creating a green image of the company brand, service security, network security, user privacy, preventive maintenance, visibility of material, information, and financial flows throughout the supply chain, replenishment of needed materials, warranty for IoT-based equipment and services, managerial capabilities, repairability of equipment, and top management support. This study is consistent with the findings of many previous studies (Bhagawati et al., 2019; Chen et al., 2022; Nozari & Aliahmadi, 2022), and its most significant contribution is the holistic examination of the crucial factors contributing to success, particularly at the supply chain level, in a single comprehensive research effort.

To create a conceptual model and extract potential latent factors, an exploratory factor analysis method was used. As a result, the factors were categorized into eight distinct groups: technical, economic, security, legal, cultural and social, environmental, applicability of IoT throughout the supply chain, and implementation of IoT applications. Then, a confirmatory factor analysis method was employed to validate the obtained model. In the final step, the grey DEMATEL method was used to determine the most influenced and influential factors and also the overall relationships among them. According to the results, the factors "implementation of IoT applications" and "economic" were the most influential, while the factors "applicability of IoT throughout the supply chain" and "technical" were the most influenced ones. Additionally, the findings of this method indicate that all factors, except for "technical" and "legal", have been influenced by other factors.

The factors outlined highlight that while the successful implementation of the IoT in the food supply chain largely depends on the actions of companies, a significant portion of it also falls within the realm of governmental authorities and institutions. Therefore, it is recommended that these entities facilitate the implementation of IoT in the food supply chain by regulating policies and providing guidance on optimal energy use, increasing network capacity, standardization (including architectural standards, program requirements standards, communication protocol standards, identification standards, security standards, application standards, data standards, and information processing standards), and strengthening financial regulations for real-time monitoring of pollutants (air, water, sound, etc.). On the other hand, this research focuses on the company "Amadeh Laziz" and its supply chain, deriving findings and results from the opinions and experiences of its employees in the context of the food supply chain in Iran. Therefore, it is suggested that future researchers, in their studies, complement or modify the proposed model by examining other companies active in the food industry in different geographical areas. Also, according to the identification of Key Success Factors to Implement IoT in the Food Supply Chain, importance-performance analysis (Mohaghar et al., 2022; Shojaei et al., 2023) can be used to prioritize implementation strategies.

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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References

Abass, T., Eruaga, M. A., Itua, E. O., & Bature, J. T. (2024). Advancing food safety through IoT: Real-time monitoring and control systems. *International Medical Science Research Journal, 4*(3), 276-283.

Abdirad, M., & Krishnan, K. (2021). Industry 4.0 in logistics and supply chain management: A systematic literature review. *Engineering Management Journal, 33*(3), 187-201.

Adamashvili, N., Zhizhilashvili, N., & Tricase, C. (2024). The integration of the Internet of Things, artificial intelligence, and blockchain technology for advancing the wine supply chain. *Computers, 13*(3), 72.

Adhicandra, I., Tanwir, T., Asfahani, A., Sitopu, J. W., & Irawan, F. (2024). Latest innovations in Internet of Things (IoT): Digital transformation across industries. *Innovative: Journal of Social Science Research, 4*(3), 1027-1037.

Ahmed, S., Kalsoom, T., Ramzan, N., Pervez, Z., Azmat, M., Zeb, B., & Ur Rehman, M. (2021). Towards supply chain visibility using Internet of Things: A dyadic analysis review. *Sensors, 21*(12), 4158.

Ahmetoglu, S., Che Cob, Z., & Ali, N. A. (2022). A systematic review of Internet of Things adoption in organizations: Taxonomy, benefits, challenges and critical factors. *Applied Sciences, 12*(9), 4117.

Ajayi, S., Loureiro, S. M. C., & Langaro, D. (2023). Internet of Things and consumer engagement in retail: State-of-the-art and future directions. *EuroMed Journal of Business, 18*(3), 397-423.

Aldossari, M. Q., & Sidorova, A. (2020). Consumer acceptance of Internet of Things (IoT): Smart home context. *Journal of Computer Information Systems, 60*(6), 507-517.

Asghari Zade, E., Safari, H., Abdollahi, B., & Ghasemi, R. (2011). Canonical correlation analysis between enabler and results in EFQM Model: A case study in TAVANIR Company in Iran. *European Journal of Social Sciences, 21*(3), 483-492.

Ayvaz, S., & Alpay, K. (2021). Predictive maintenance system for production lines in manufacturing: A machine learning approach using IoT data in real-time. *Expert Systems with Applications, 173*, 114598.

Bafandegan Emroozi, V., Roozkhosh, P., Modares, A., & Roozkhosh, F. (2023). Selecting green suppliers by considering the internet of things and CMCDM approach. *Process Integration and Optimization for Sustainability, 7*, 1167–1189.

Bazargan, A., Ghasemi, R., Eftekhar Ardebili, M., & Zarei, M. (2017). The relationship between 'higher education and training' and 'business sophistication'. *Iranian Economic Review, 21*(2), 319–341.

Ben-Daya, M., Hassini, E., Bahroun, Z., & Banimfreg, B. H. (2020). The role of internet of things in food supply chain quality management: A review. *Quality Management Journal, 28*(1), 17–40.

Bhagawati, M. T., Manavalan, E., Jayakrishna, K., & Venkumar, P. (2019). Identifying key success factors of sustainability in supply chain management for industry 4.0 using DEMATEL method. In *Proceedings of the International Conference on Intelligent Manufacturing and Automation: ICIMA 2018* (pp. 583–591). Springer Singapore.

Birkel, H. S., & Hartmann, E. (2019). Impact of IoT challenges and risks for SCM. *Supply Chain Management: An International Journal, 24*(1), 39–61.

Bouzembrak, Y., Klüche, M., Gavai, A., & Marvin, H. J. (2019). Internet of things in food safety: Literature review and a bibliometric analysis. *Trends in Food Science & Technology, 94*, 54–64.

Cabrini, F. H., Valiante Filho, F., Rito, P., Barros Filho, A., Sargento, S., Venâncio Neto, A., & Kofuji, S. T. (2021). Enabling the industrial Internet of Things to cloud continuum in a real city environment. *Sensors, 21*(22), 7707.

Cammarano, A., Varriale, V., Michelino, F., & Caputo, M. (2023). Blockchain as enabling factor for implementing RFID and IoT technologies in VMI: A simulation on the Parmigiano Reggiano supply chain. *Operations Management Research, 16*(2), 726–754.

Chen, X., Chen, R., & Yang, C. (2022). Research on key success factors of intelligent logistics based on IoT technology. *The Journal of Supercomputing, 78*(3), 3905–3939.

Cheng, T., Abowd, G. D., Oh, H., & Hester, J. (2023, July). Transient Internet of Things: Redesigning the lifetime of electronics for a more sustainable networked environment. In *Proceedings of the 2nd Workshop on Sustainable Computer Systems* (pp. 1–8). https://doi.org/10.1145/3604930.3605723

Elvy, S. A. (2017). Hybrid transactions and the Internet of Things: Goods, services, or software. *Washington and Lee Law Review, 74*, 77. Retrieved from https://heinonline.org/HOL/LandingPage?handle=hein.journals/waslee74&div=6&id=&page=

Fatorachian, H., & Kazemi, H. (2021). Impact of Industry 4.0 on supply chain performance. *Production Planning & Control, 32*(1), 63–81.

Fernandez, C. M., Alves, J., Gaspar, P. D., Lima, T. M., & Silva, P. D. (2023). Innovative processes in smart packaging: A systematic review. *Journal of the Science of Food and Agriculture, 103*(3), 986–1003.

Gallab, M., Di Nardo, M., & Naciri, L. (2024). Navigating contemporary challenges and future prospects in digital industry evolution. *Discover Applied Sciences, 6*(5), 259.

Gamil, Y., Abdullah, M. A., Abd Rahman, I., & Asad, M. M. (2020). Internet of Things in construction industry revolution 4.0: Recent trends and challenges in the Malaysian context. *Journal of Engineering, Design and Technology, 18*(5), 1091–1102.

Ghasemi, R., & Mehregan, M. J. (2014). Relationship between macroeconomic environment and financial market development. *European Journal of Economics, Finance and Administrative Sciences, 65*, 64–76.

Ghasemi, R., Alidoosti, A., Hosnavi, R., & Norouzian Reykandeh, J. (2018). Identifying and prioritizing humanitarian supply chain practices to supply food before an earthquake. *Industrial Management Journal, 10*(1), 1–16.

Ghasemi, R., Hashemi-Petroudi, S. H., Mahbanooei, B., & Mousavi-Kiasari, Z. (2013). Relationship between infrastructure and technological readiness based on Global Competitiveness Report: A guidance for developing countries. In *7th National Conference on Electronic Commerce & Economy* (pp. 19–21).

Ghasemi, R., Mohaghar, A., Safari, H., & Akbari Jokar, M. R. (2016). Prioritizing the applications of Internet of Things technology in the healthcare sector in Iran: A driver for sustainable development. *Journal of Information Technology Management, 8*(1), 155–176.

Goli, A., Babaee Tirkolaee, E., Golmohammadi, A. M., et al. (2023). A robust optimization model to design an IoT-based sustainable supply chain network with flexibility. *Central European Journal of Operations Research*, 1–22.

Gu, F., Ma, B., Guo, J., Summers, P. A., & Hall, P. (2017). Internet of Things and Big Data as potential solutions to the problems in waste electrical and electronic equipment management: An exploratory study. *Waste Management, 68*, 434–448.

Gupta, B. B., & Quamara, M. (2020). An overview of Internet of Things (IoT): Architectural aspects, challenges, and protocols. *Concurrency and Computation: Practice and Experience, 32*(21), e4946.

Haghighi, S. M., Torabi, S. A., & Ghasemi, R. (2016). An integrated approach for performance evaluation in sustainable supply chain networks (with a case study). *Journal of Cleaner Production, 137*, 579–597.

Hawash, B., Mokhtar, U. A., Yusof, Z. M., Mukred, M., & Gaid, A. S. (2021, March). Factors affecting Internet of Things (IoT) adoption in the Yemeni oil and gas sector. In *2021 International Conference of Technology, Science and Administration (ICTSA)* (pp. 1–7). IEEE. https://doi.org/10.1109/ICTSA52017.2021.9406527

Hoorshad, A., Safari, H., & Ghasemi, R. (2023). Developing smart supply chain management model in fast-moving consumer goods industry (FMCG). *Journal of Industrial Management Perspective, 13*(4), 108–148.

Hossein Motlagh, N., Mohammadrezaei, M., Hunt, J., & Zakeri, B. (2020). Internet of Things (IoT) and the energy sector. *Energies, 13*(2), 494.

Hsu, C. W., & Yeh, C. C. (2017). Understanding the factors affecting the adoption of the Internet of Things. *Technology Analysis & Strategic Management, 29*(9), 1089–1102.

Hsu, C. W., Lu, J. H., Wang, T. C., Huang, J. C., & Shu, M. H. (2023). Industrial Internet of Things on integrated preventive maintenance and enterprise-resource-planning systems: A case study of fastener forming manufacturing processes. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 237*(6-7), 1100–1114.

Hu, R., Shahzad, F., Abbas, A., & Liu, X. (2022). Decoupling the influence of eco-sustainability motivations in the adoption of the green industrial IoT and the impact of advanced manufacturing technologies. *Journal of Cleaner Production, 339*, 130708.

Infante-Moro, A., Infante-Moro, J. C., & Gallardo-Pérez, J. (2021). Key factors in the implementation of the Internet of Things in the hotel sector. *Applied Sciences, 11*(7), 2924.

Ishak, M. S., & AlSalem, Y. Z. (2023). Critical factors of failure and success of using IoT in project management. *Journal for ReAttach Therapy and Developmental Diversities, 6*(10s(2)), 422–438.

Jafarnejad, A., Ghasemi, R., & Abdullahi, B. (2011, November). Relationship between "Financial Market Development" and "Technological Readiness" based on Global Competitiveness Report: A guidance for developing countries. In *5th National Conference on Management of Technology* (pp. 23–25).

Jafarnejad, A., Ghasemi, R., & Ghasemi, M. R. (2010). Developing and designing a new technology for drilling on the small area. In *4th National Conference on Management of Technology* (pp. 8–9). Tehran, Iran.

Jafarnejad, A., Ghasemi, R., Abdollahi, B., & Esmailzadeh, A. (2013). Relationship between macroeconomic environment and technological readiness: A secondary analysis of countries' global competitiveness. *International Journal of Management Perspective*.

Jafarnejad, A., Rahayu, G. H. N. N., Ghasemi, R., & Bahrami, F. (2014). Relationship between knowledge management process capabilities and supply chain relations quality. In *6th International Conference on Operations and Supply Chain Management* (pp. 1072–1085).

Jagtap, S., & Rahimifard, S. (2019). Unlocking the potential of the Internet of Things to improve resource efficiency in food supply chains. In *Innovative Approaches and Applications for Sustainable Rural Development: 8th International Conference, HAICTA 2017* (pp. 287–301). Springer International Publishing. https://doi.org/10.1007/978-3-030-02312-6_17

Jamalian, A., Ghadikolaei, A. S., Zarei, M., & Ghasemi, R. (2018). Sustainable supplier selection by way of managing knowledge: A case of the automotive industry. *International Journal of Intelligent Enterprise, 5*(1–2), 125–140.

Janssen, M., Luthra, S., Mangla, S., Rana, N. P., & Dwivedi, Y. K. (2019). Challenges for adopting and implementing IoT in smart cities: An integrated MICMAC-ISM approach. *Internet Research, 29*(6), 1589–1616.

Kamble, S. S., Gunasekaran, A., Parekh, H., & Joshi, S. (2019). Modeling the Internet of Things adoption barriers in food retail supply chains. *Journal of Retailing and Consumer Services, 48*, 154–168.

Kannan, V., Muthurajan, M., Dutta, S., Moses, J. A., & Anandharamakrishnan, C. (2024). Big data, Internet of Things, and cloud computing in the food industry. In *Emerging technologies for the food industry* (pp. 93–131). Apple Academic Press.

Karimi, T., Azar, A., Mohebban, B., & Ghasemi, R. (2022). Developing an Internet of Things-based intelligent transportation technology roadmap in the food cold supply chain. *Industrial Management Journal, 14*(2), 195–219.

Kaur, H. (2021). Modelling Internet of Things driven sustainable food security system. *Benchmarking: An International Journal, 28*(5), 1740–1760.

Kawai, T. (2018). Proposing a theory of dynamic managerial capabilities─For coping with the era of IoT─. *Journal of Strategic Management Studies, 10*(1), 35–52.

Khan, A., Jhanjhi, N. Z., Haji, D. H. T. B. A., & Omar, H. A. H. B. H. (2024). Internet of Things (IoT) impact on inventory management: A review. *Cybersecurity Measures for Logistics Industry Framework*, 224–247.

Khan, S., Singh, R., Khan, S., & Ngah, A. H. (2023). Unearthing the barriers of Internet of Things adoption in food supply chain: A developing country perspective. *Green Technologies and Sustainability, 1*(2), 100023.

Kim, S., Pérez-Castillo, R., Caballero, I., & Lee, D. (2022). Organizational process maturity model for IoT data quality management. *Journal of Industrial Information Integration, 26*, 100256.

Kodan, R., Parmar, P., & Pathania, S. (2020). Internet of Things for food sector: Status quo and projected potential. *Food Reviews International, 36*(6), 584–600.

Končar, J., Grubor, A., Marić, R., Vučenović, S., & Vukmirović, G. (2020). Setbacks to IoT implementation in the function of FMCG supply chain sustainability during COVID-19 pandemic. *Sustainability, 12*(18), 7391.

Kumar, A., Mangla, S. K., & Kumar, P. (2024). Barriers for adoption of Industry 4.0 in sustainable food supply chain: A circular economy perspective. *International Journal of Productivity and Performance Management, 73*(2), 385–411.

Lawal, K., & Rafsanjani, H. N. (2022). Trends, benefits, risks, and challenges of IoT implementation in residential and commercial buildings. *Energy and Built Environment, 3*(3), 251–266.

Lee, I. (2019). The Internet of Things for enterprises: An ecosystem, architecture, and IoT service business model. *Internet of Things, 7*, 100078.

Lin, D., Lee, C. K. M., & Lin, K. (2016, December). Research on effect factors evaluation of Internet of Things (IoT) adoption in Chinese agricultural supply chain. In *2016 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)* (pp. 612–615). IEEE. https://doi.org/10.1109/IEEM.2016.7797948

Luthra, S., Garg, D., Mangla, S. K., & Berwal, Y. P. S. (2018). Analyzing challenges to Internet of Things (IoT) adoption and diffusion: An Indian context. *Procedia Computer Science, 125*, 733–739.

Mahajan, P. S., Raut, R. D., Kumar, P. R., & Singh, V. (2024). Inventory management and TQM practices for better firm performance: A systematic and bibliometric review. *The TQM Journal, 36*(2), 405–430.

Malik, P. K., Sharma, R., Singh, R., Gehlot, A., Satapathy, S. C., Alnumay, W. S., ... & Nayak, J. (2021). Industrial Internet of Things and its applications in Industry 4.0: State of the art. *Computer Communications, 166*, 125–139.

Mashayekhy, Y., Babaei, A., Yuan, X. M., & Xue, A. (2022). Impact of Internet of Things (IoT) on inventory management: A literature survey. *Logistics, 6*(2), 33.

Mathaba, S., Adigun, M., Oladosu, J., & Oki, O. (2017). On the use of the Internet of Things and Web 2.0 in inventory management. *Journal of Intelligent & Fuzzy Systems, 32*(4), 3091–3101.

Maulana, H., Ginting, S. L. B., Aryan, P., Fadillah, M. R., & Kamal, R. N. (2021). Utilization of Internet of Things on food supply chains in food industry. *International Journal of Informatics, Information System and Computer Engineering (INJIISCOM), 2*(1), 103–112.

Mehregan, M. R., Ghasemi, R., Amirnequiee, S., & Zarei, M. (2016, December). Developing DEMATEL-CCA hybrid algorithm approach to analyze the causal relations on global competitiveness pillars. In *4th International Conference on Strategic Management*, Faculty of Management, University of Tehran.

Misra, N. N., Dixit, Y., Al-Mallahi, A., Bhullar, M. S., Upadhyay, R., & Martynenko, A. (2020). IoT, big data, and artificial intelligence in agriculture and food industry. *IEEE Internet of Things Journal, 9*(9), 6305–6324.

Mohaghar, A., & Ghasemi, R. (2011a). A conceptual model for corporate strategy and supply chain performance by structural equation modeling: A case study in the Iranian automotive industry. *European Journal of Social Sciences, 22*(4), 519–530.

Mohaghar, A., & Ghasemi, R. (2011b). A conceptual model for supply chain relations quality and supply chain performance by structural equation modeling: A case study in the Iranian automotive industry. *European Journal of Social Sciences, 21*(3), 456–470.

Mohaghar, A., Ghasemi, R., Abdullahi, B., Esfandi, N., & Jamalian, A. (2011). Canonical correlation analysis between supply chain relationship quality and cooperative strategy: A case study in the Iranian automotive industry. *European Journal of Social Sciences, 26*(1), 132–145.

Mohaghar, A., Ghasemi, R., Toosi, H., & Sheykhizadeh, M. (2022). Evaluating city of knowledge's project management office functions using BWM and importance-performance analysis. *Journal of Decisions and Operations Research, 7*(4), 530–549.

Mohaghar, A., Heydarzadeh Moghaddam, H., & Ghasemi, R. (2023). Developing a model to optimize maximum coverage of roadside units placement in vehicular ad-hoc network for intelligent transportation system. *Journal of Industrial Management Perspective, 13*(2), 211–240.

Mohaghar, A., Sadeghi Moghadam, M. R., Ghourchi Beigi, R., & Ghasemi, R. (2021). IoT-based services in the banking industry using a business continuity management approach. *Journal of Information Technology Management, 13*(4), 16–38.

Mohaghar, A., Safari, H., Ghasemi, R., Abdullahi, B., & Maleki, M. H. (2011). Canonical correlation analysis between supply chain relationship quality and supply chain performance: A case study in the Iranian automotive industry. *International Bulletin of Business Administration, 10*(10), 122–134.

Mohammadzadeh, A. K., Ghafoori, S., Mohammadian, A., Mohammadkazemi, R., Mahbanooei, B., & Ghasemi, R. (2018). A fuzzy analytic network process (FANP) approach for prioritizing Internet of Things challenges in Iran. *Technology in Society, 53*, 124–134.

Momeni, M., Monavarian, A., Shaabani, E., & Ghasemi, R. (2011a). A conceptual model for knowledge management process capabilities and core competencies by SEM: The case of Iranian automotive industry. *European Journal of Social Sciences, 22*(4), 473–489.

Momeni, M., Shaabani, E., Ghasemi, R., & Abdullahi, B. (2011b). Canonical correlation analysis between knowledge management and core competencies: A case study in the Iranian automotive industry. *American Journal of Scientific Research, 25*(1), 70–81.

Narwane, V. S., Gunasekaran, A., & Gardas, B. B. (2022). Unlocking adoption challenges of IoT in Indian agricultural and food supply chain. *Smart Agricultural Technology, 2*, 100035.

Nasrollahi, M., Ghadikolaei, A. S., Ghasemi, R., Sheykhizadeh, M., & Abdi, M. (2022). Identification and prioritization of connected vehicle technologies for sustainable development in Iran. *Technology in Society, 68*, 101829.

Nerkar, P. M., Shinde, S. S., Liyakat, K. K. S., Desai, S., & Kazi, S. S. L. (2023). Monitoring fresh fruit and food using IoT and machine learning to improve food safety and quality. *Tuijin Jishu/Journal of Propulsion Technology, 44*(3), 2927–2931.

Ngai, E. W. T., Poon, J. K. L., & Chan, Y. H. C. (2007). Empirical examination of the adoption of WebCT using TAM. *Computers & Education, 48*(2), 250–267.

Nižetić, S., Šolić, P., Gonzalez-De, D. L. D. I., & Patrono, L. (2020). Internet of Things (IoT): Opportunities, issues, and challenges towards a smart and sustainable future. *Journal of Cleaner Production, 274*, 122877.

Nozari, H., & Aliahmadi, A. (2022). Lean supply chain based on IoT and blockchain: Quantitative analysis of critical success factors (CSF). *Journal of Industrial and Systems Engineering, 14*(3), 149–167.

Nozari, H., Fallah, M., Szmelter-Jarosz, A., & Krzemiński, M. (2021). Analysis of security criteria for IoT-based supply chain: A case study of FMCG industries. *Central European Management Journal, 29*(4), 149–171.

Onyeaka, H., Tamasiga, P., Nwauzoma, U. M., Miri, T., Juliet, U. C., Nwaiwu, O., & Akinsemolu, A. A. (2023). Using artificial intelligence to tackle food waste and enhance the circular economy: Maximising resource efficiency and minimising environmental impact: A review. *Sustainability, 15*(13), 10482.

Pérez-Padillo, J., Puig, F., Morillo, J. G., & Montesinos, P. (2022). IoT platform for failure management in water transmission systems. *Expert Systems with Applications, 199*, 116974.

Persis, D. J., Venkatesh, V. G., Sreedharan, V. R., Shi, Y., & Sankaranarayanan, B. (2021). Modelling and analysing the impact of circular economy, Internet of Things, and ethical business practices in the VUCA world: Evidence from the food processing industry. *Journal of Cleaner Production, 301*, 126871.

Pivoto, D. G., De Almeida, L. F., da Rosa Righi, R., Rodrigues, J. J., Lugli, A. B., & Alberti, A. M. (2021). Cyber-physical systems architectures for industrial Internet of Things applications in Industry 4.0: A literature review. *Journal of Manufacturing Systems, 58*, 176–192.

Purnama, S., & Sejati, W. (2023). Internet of Things, big data, and artificial intelligence in the food and agriculture sector. *International Transactions on Artificial Intelligence, 1*(2), 156–174.

Ramanathan, R., Duan, Y., Ajmal, T., Pelc, K., Gillespie, J., Ahmadzadeh, S., ... & Ramanathan, U. (2023). Motivations and challenges for food companies in using IoT sensors for reducing food waste: Some insights and a road map for the future. *Sustainability, 15*(2), 1665.

Rastegar, A. A., Mahbanooei, B., & Ghasemi, R. (2012, May). Canonical correlation analysis between technological readiness and labor market efficiency: A secondary analysis of countries global competitiveness in 2011–2012. In *13th International Conference on Econometrics, Operations Research and Statistics (ICEOS-2012)* (pp. 24–26).

Razavi, S. M., Abdi, M., Amirnequiee, S., & Ghasemi, R. (2016). The impact of supply chain relationship quality and cooperative strategy on strategic purchasing. *Journal of Logistics Management, 5*(1), 6–15.

Razavi, S. M., Abdollahi, B., Ghasemi, R., & Shafie, H. (2012). Relationship between innovation and business sophistication: A secondary analysis of countries global competitiveness. *European Journal of Scientific Research, 79*(1), 29–39.

Razavi, S. M., Ghasemi, R., & Mahbanooei, B. (2015). Prioritizing the Middle East countries based on goods market efficiency indicators. In *International Research Conference on Business, Economics and Social Sciences (IRC-2015)*, Istanbul, Turkey (pp. 27–28 February).

Razavi, S. M., Ghasemi, R., Abdullahi, B., & Kashani, M. (2011). Relationship between technological readiness and innovation: A secondary analysis of countries global competitiveness. *European Journal of Scientific Research, 59*(3), 318–328.

Rehman, K. U., Andleeb, S., Ashfaq, M., Akram, N., & Akram, M. W. (2023). Blockchain-enabled smart agriculture: Enhancing data-driven decision making and ensuring food security. *Journal of Cleaner Production, 427*, 138900.

Rejeb, A., Rejeb, K., Zailani, S., Treiblmaier, H., & Hand, K. J. (2021). Integrating the Internet of Things in the halal food supply chain: A systematic literature review and research agenda. *Internet of Things, 13*, 100361.

Sadeghi Moghadam, M. R., Norouzian Reykandeh, J., & Ghasemi, R. (2017). Explanation of the importance-performance dimensions and components of humanitarian supply chain in post-disaster. *Organizational Resources Management Research, 7*(3), 157–176.

Safari, H., Abdollahi, B., & Ghasemi, R. (2012). Canonical correlation analysis between people criterion and people results criterion in EFQM model. *Total Quality Management & Business Excellence, 23*(5-6), 541–555.

Sallam, K., Mohamed, M., & Mohamed, A. W. (2023). Internet of Things (IoT) in supply chain management: Challenges, opportunities, and best practices. *Sustainable Machine Intelligence Journal, 2*, 3–1.

Seyedghorban, Z., Tahernejad, H., Meriton, R., & Graham, G. (2020). Supply chain digitalization: Past, present, and future. *Production Planning & Control, 31*(2-3), 96–114.

Shah, S., & Ververi, A. (2018, November). Evaluation of Internet of Things (IoT) and its impacts on global supply chains. In *2018 IEEE International Conference on Technology Management,* *Operations and Decisions (ICTMOD)* (pp. 160–165). IEEE. https://doi.org/10.1155/2022/5298873

Shamayleh, A., Awad, M., & Farhat, J. (2020). IoT-based predictive maintenance management of medical equipment. *Journal of Medical Systems, 44*(4), 72.

Sharma, M., Joshi, S., Kannan, D., Govindan, K., Singh, R., & Purohit, H. C. (2020). Internet of Things (IoT) adoption barriers of smart cities' waste management: An Indian context. *Journal of Cleaner Production, 270*, 122047.

Sheykhzadeh, M., Ghasemi, R., Vandchali, H. R., Sepehri, A., & Torabi, S. A. (2024). A hybrid decision-making framework for a supplier selection problem based on lean, agile, resilience, and green criteria: A case study of a pharmaceutical industry. *Environment, Development and Sustainability*, 1–28.

Shojaei, A. A., Mahbanooei, B., Farahani, A., & Pourezzat, A. A. (2023). Organizational ethics indicators in Iranian hospitals: An importance-performance analysis. *Iranian Journal of Nursing and Midwifery Research, 28*(5), 593–603.

Sigwart, M., Borkowski, M., Peise, M., Schulte, S., & Tai, S. (2019, October). Blockchain-based data provenance for the Internet of Things. In *Proceedings of the 9th International Conference on the Internet of Things* (pp. 1–8). Association for Computing Machinery.

Singh, R., Khan, S., Dsilva, J., & Centobelli, P. (2023). Blockchain integrated IoT for food supply chain: A grey-based Delphi-DEMATEL approach. *Applied Sciences, 13*(2), 1079.

Sinha, B. B., & Dhanalakshmi, R. (2022). Recent advancements and challenges of Internet of Things in smart agriculture: A survey. *Future Generation Computer Systems, 126*, 169–184.

Stefanini, R., & Vignali, G. (2024). The influence of Industry 4.0 enabling technologies on social, economic, and environmental sustainability of the food sector. *International Journal of Production Research, 62*(10), 3800–3817.

Tavana, M., Khalili Nasr, A., Santos-Arteaga, F. J., Saberi, E., & Mina, H. (2023). An optimization model with a Lagrangian relaxation algorithm for artificial Internet of Things-enabled sustainable circular supply chain networks. *Annals of Operations Research*, 1–36.

Tripathi, S., & Pandit, L. (2019). Analysis of factors influencing adoption of Internet of Things: A system dynamics approach. *Theoretical Economics Letters, 9*(07), 2606–2622.

Tyagi, A. K., Dananjayan, S., Agarwal, D., & Thariq Ahmed, H. F. (2023). Blockchain—Internet of Things applications: Opportunities and challenges for Industry 4.0 and Society 5.0. *Sensors, 23*(2), 947.

Vares, H., Parvandi, Y., Ghasemi, R., & Abdullahi, B. (2011). Transition from an efficiency-driven economy to an innovation-driven economy: A secondary analysis of countries' global competitiveness. *European Journal of Economics, Finance and Administrative Sciences, 31*, 124–132.

Vares, S. H., Parvandi, Y., & Ghasemi, R. (2012). Improving doing business in order to achieve the economic vision of IRI 2025: An analysis based on TOPSIS and entropy techniques. *Journal of Business Management, 4*(1), 121–138.

Villa-Henriksen, A., Edwards, G. T., Pesonen, L. A., Green, O., & Sørensen, C. A. G. (2020). Internet of Things in arable farming: Implementation, applications, challenges, and potential. *Biosystems Engineering, 191*, 60–84.

Wanasinghe, T. R., Gosine, R. G., James, L. A., Mann, G. K., De Silva, O., & Warrian, P. J. (2020). The Internet of Things in the oil and gas industry: A systematic review. *IEEE Internet of Things Journal, 7*(9), 8654–8673.

Wang, K., Zhao, Y., Gangadhari, R. K., & Li, Z. (2021). Analyzing the adoption challenges of the Internet of Things (IoT) and artificial intelligence (AI) for smart cities in China. *Sustainability, 13*(19), 10983.

Weißhuhn, S., & Hoberg, K. (2021). Designing smart replenishment systems: Internet-of-Things technology for vendor-managed inventory at end consumers. *European Journal of Operational Research, 295*(3), 949–964.

Wójcicki, K., Biegańska, M., Paliwoda, B., & Górna, J. (2022). Internet of Things in industry: Research profiling, application, challenges, and opportunities—a review. *Energies, 15*(5), 1806.

Xie, Y., Yin, Y., Xue, W., Shi, H., & Chong, D. (2020). Intelligent supply chain performance measurement in Industry 4.0. *Systems Research and Behavioral Science, 37*(4), 711–718.

Yousefi, D., Pirannejad, A., & Jamipour, M. (2023). Investigating the susceptibility of human resource management to the Internet of Things. *Journal of Public Administration, 15*(2), 344–363.

Yousefi, H., Su, H. M., Imani, S. M., Alkhaldi, K., Filipe, C. D. M., & Didar, T. F. (2019). Intelligent food packaging: A review of smart sensing technologies for monitoring food quality. *ACS Sensors, 4*(4), 808–821.

Yuehong, Y. I. N., Zeng, Y., Chen, X., & Fan, Y. (2016). The Internet of Things in healthcare: An overview. *Journal of Industrial Information Integration, 1*, 3–13.

Zadtootaghaj, P., Mohammadian, A., Mahbanooei, B., & Ghasemi, R. (2019). Internet of Things: A survey for individuals' e-health applications. *Journal of Information Technology Management, 11*(1), 102–129.

Zarei, M., Jamalian, A., & Ghasemi, R. (2017). Industrial guidelines for stimulating entrepreneurship with the Internet of Things. In *The Internet of Things in the Modern Business Environment* (pp. 147–166). IGI Global.

Zarei, M., Mohammadian, A., & Ghasemi, R. (2016). Internet of Things in industries: A survey for sustainable development. *International Journal of Innovation and Sustainable Development, 10*(4), 419–442.

Zhang, J., Han, S., & Shan, J. (2022). An empirical analysis of the impact of environmental protection tax on corporate earnings management. *Mobile Information Systems, 2022*(1), 5298873.

Zhu, M., & Shang, J. (2022). Remote monitoring and management system of intelligent agriculture under the Internet of Things and deep learning. *Wireless Communications and Mobile Computing, 2022*(1), 1206677.

Ziatdinov, R., Atteraya, M. S., & Nabiyev, R. (2024). The Fifth Industrial Revolution as a transformative step towards Society 5.0. *Societies, 14*(2), 19.

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