Int. J. Nonlinear Anal. Appl. 16 (2025) 2, 37–49
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2024.33517.4996

Unveiling key drivers of supply chain sustainability in the telecom sector: An information systems perspective

Mohammadreza Shahriari

Faculty of Industrial Management, South Tehran Branch, Islamic Azad University, Tehran, Iran

(Communicated by Madjid Eshaghi Gordji)

Abstract

The telecommunications industry plays a crucial role in global connectivity and communication. As sustainability concerns become increasingly important, telecom companies must prioritize sustainable practices throughout their supply chains. Information systems have emerged as powerful tools for enhancing supply chain sustainability in this industry. This study utilizes the VIKOR method to analyze the factors that significantly impact information systems on supply chain sustainability in the telecom sector. The analysis demonstrates that real-time data visibility and inventory management are the most influential factors in improving supply chain sustainability in the telecom industry. These factors enable companies to track and optimize inventory levels effectively, minimize waste, and enhance resource utilization.

Keywords: information systems, sustainable supply chain, vikor, e-business, environmental performance
2020 MSC: 90B06, 68U35

1 Introduction

The effect of information systems on supply chain sustainability is a topic of significant interest and importance in today's business environment. Information systems enhance supply chain sustainability performance by providing real-time data, improving communication and collaboration, enabling transparency, and supporting decision-making processes. In this context, supply chain sustainability refers to integrating economic, environmental, and social considerations into supply chain operations to achieve long-term viability.

Information systems contribute to supply chain sustainability through improved visibility and transparency. By capturing and analyzing data at various supply chain stages, information systems enable companies to track and monitor their environmental and social impacts. For example, sensors and IoT technologies can collect data on energy consumption, waste generation, carbon emissions, and worker conditions. This data helps identify inefficiencies, areas for improvement, and potential risks, allowing companies to implement targeted sustainability initiatives.

Furthermore, information systems facilitate collaboration and information sharing among supply chain partners. By connecting different entities in the supply chain, such as suppliers, manufacturers, distributors, and customers, information systems enable the exchange of real-time information on inventory levels, production schedules, and demand forecasts. This collaborative approach helps optimize processes, reduce waste, and minimize the supply chain's environmental footprint.

Email address: shahriari.mr@gmail.com (Mohammadreza Shahriari)

Received: February 2024 *Accepted:* April 2024

Information systems provide insights and analytics that support sustainable decision-making. For instance, advanced analytics can help identify the most sustainable transportation routes, optimize packaging to minimize waste, and select suppliers with strong sustainability practices. These data-driven decisions contribute to reducing energy consumption, carbon emissions, and resource depletion throughout the supply chain.

Moreover, information systems enable effective stakeholder engagement and communication. They allow companies to communicate their sustainability initiatives, achievements, and progress to customers, investors, and the public. This transparency enhances trust and credibility, improving reputation and brand value.

Another area where information systems positively impact supply chain sustainability is risk management. By monitoring and analyzing data, companies can identify potential risks related to sustainability issues, such as regulatory compliance, ethical sourcing, and environmental disruptions. Timely identifying these risks allows proactive measures to be taken, minimizing potential negative impacts on the supply chain and the environment.

It is worth noting that information systems are continuously evolving, incorporating emerging technologies such as artificial intelligence, blockchain, and big data analytics. These technologies further enhance supply chain sustainability by enabling automated data collection, advanced analytics for predictive modeling, and secure traceability of products and materials.

In conclusion, information systems profoundly affect supply chain sustainability by improving visibility, enabling collaboration, supporting data-driven decision-making, enhancing stakeholder communication, and facilitating risk management. As businesses strive to achieve sustainability goals, leveraging information systems becomes essential for optimizing supply chain operations, reducing environmental impacts, ensuring ethical practices, and creating long-term value for all stakeholders involved.

The effective utilization of information systems is crucial for organizations to achieve their goals efficiently and cost-effectively. Over the years, information systems have undergone significant advancements. Supply chain management encompasses various activities, such as material sourcing, production scheduling, and physical distribution, all of which rely on efficient information flows. Extensive literature exists on the adoption of information systems, such as Material Requirements Planning (MRP), Manufacturing Resource Planning (MRPII), Enterprise Resource Planning (ERP), Supplier Relationship Management (SRM), Customer Relationship Management (CRM), and others, to enhance supply chain management [25].

In addition, a growing body of research focuses on integrating sustainability practices into supply chain management. However, this integration poses a more complex challenge than implementing sustainability within a single firm, as it involves multiple stakeholders in the supply chain, including suppliers, focal firms, distributors, retailers, and customers [1]. Pressures from government regulators, community activists, NGOs, and global competition have prompted many companies to adopt sustainability practices to varying degrees [10].

Despite extensive research on the use of information systems and supply chain sustainability, further investigation into the specific impact of information systems on supply chain sustainability is still needed. This paper aims to fill this research gap by examining the effects of different information systems on supply chain sustainability using the VIKOR method.

The study begins by presenting relevant theoretical concepts and literature. Next, it identifies key information systems and supply chain sustainability metrics based on a comprehensive review of existing literature and expert opinions. Subsequently, it employs an exploratory research approach, utilizing the VIKOR method to investigate the impact of information systems on supply chain sustainability. The study's findings and recommendations are presented in the final sections, providing valuable insights for practitioners and decision-makers in the field of supply chain sustainability.

2 Background

2.1 Information systems

An information system can be defined technically as a set of interrelated components that collect (or retrieve), process, store, and distribute information to support decision-making and control in an organization. It is a fundamental tool for managing and utilizing data within a business context. The primary purpose of an information system is to support decision-making, coordination, and control processes. By providing access to relevant and timely information, these systems empower managers and workers to analyze problems, gain insights, visualize complex subjects, and create innovative products. Moreover, information systems are vital in enabling businesses to streamline their operations,

bringing together various functions and processes into a cohesive and efficient unit. One of the key benefits of information systems is their ability to provide critical data to support business decision-making. By gathering and processing data from different sources, information systems generate valuable insights that assist managers in making informed choices. These systems facilitate data collection, analysis, and presentation in meaningful ways, enabling managers to comprehensively understand their organization's performance and make strategic decisions accordingly. Additionally, information systems have a significant impact on communication within an organization. They enhance communication channels and facilitate the flow of information across different departments and hierarchical levels. By promoting efficient and effective communication, information systems contribute to better coordination and collaboration among team members, ultimately improving overall organizational productivity and performance.

Furthermore, information systems help reduce human labor by automating repetitive tasks and routine operations. This automation frees up employees' time, allowing them to focus on more value-added activities that require critical thinking, creativity, and problem-solving skills. Information systems contribute to operational efficiency and cost savings by minimizing manual effort and maximizing productivity. Over the years, information systems have undergone significant advancements. Since the 1960s, different information systems have been developed and refined to meet evolving business needs and technological capabilities. These systems have become more sophisticated, integrating advanced technologies and functionalities to enhance data processing, storage, retrieval, and analysis.

This research reviews various information systems, highlighting their evolution and impact. Table 1 provides an overview of the different information systems covered in the study, illustrating their progression and advancements over time. Such a comprehensive review enables a better understanding of information systems' transformative role in shaping how organizations operate and make decisions.

Overall, information systems are critical assets for businesses. They enable them to harness the power of data and technology to drive efficiency, informed decision-making, and organizational success. By leveraging these systems, organizations can adapt to changing market dynamics, gain a competitive edge, and achieve their short- and long-term business goals. Information systems play a vital role in facilitating decision-making and control within organizations. They consist of interconnected components that collect, process, store, and distribute data, aiming to support various functions such as problem analysis, visualization, and innovation in product development. Implementing information systems enables businesses to optimize their operations and establish a cohesive operational structure.

A study conducted by Ketikidis et al. in 2008 [25] investigated the use of information systems for logistics and supply chain management. The researchers identified several information systems that are widely used in this context, including Warehouse Management Systems (WMS), Material Requirements Planning (MRP), and barcoding. These systems were among the most popular choices for organizations seeking to enhance their logistics and supply chain operations.

One crucial aspect of information systems is their support for business decision-making processes. They provide management with essential data for informed decision-making, improving organizational communication and reducing reliance on manual labor. Information systems align with both short-term and long-term business objectives and facilitate the dissemination of complex information [26, 40]. Over the years, different information systems have significantly improved since the 1960s [43]. A detailed review of these information systems is presented in Table 2 in this research.

Numerous studies have been conducted on using information systems in logistics and supply chain management. These studies explore different aspects of information systems and their impact on supply chain operations. Here are some notable studies in this field:

Gunasekaran et al. [9]: This study examined the role of information systems in achieving supply chain integration. It highlighted the importance of information sharing, collaboration, and technologies such as Enterprise Resource Planning (ERP) and Electronic Data Interchange (EDI) in enhancing supply chain performance [28, 30, 39].

Chen and Paulraj (2004) investigated the impact of information systems on supply chain agility. They found that organizations with advanced information systems, such as real-time monitoring and decision support systems, were better equipped to respond quickly to changes in the supply chain environment [5].

Ferdows and De Meyer [8]: This study focused on the role of information systems in achieving efficient logistics operations. It highlighted the benefits of integrating information systems with logistics processes and emphasized the importance of accurate and timely information for effective logistics management. Li et al. [27]: The researchers explored information systems, particularly Customer Relationship Management (CRM) systems, in supply chain management. They found that organizations implementing CRM systems experienced improved customer satisfaction, increased sales, and enhanced collaboration with supply chain partners.

Simchi-Levi et al. [45]: This study examined the use of information systems in demand forecasting and inventory management. It discussed the benefits of using advanced forecasting models and software systems in improving forecast accuracy, reducing inventory costs, and achieving better supply chain performance. These studies, along with many others, provide valuable insights into the role of information systems in logistics and supply chain management. They highlight the benefits, challenges, and best practices associated with using various information systems to optimize supply chain operations, enhance collaboration, improve customer satisfaction, and achieve competitive advantage. In conclusion, information systems facilitate information flow, decision-making, and control within organizations. They offer many benefits, including improved communication, streamlined operations, enhanced decision-making capabilities, and effective distribution of complex information. The continuous evolution of information systems since the 1960s demonstrates their growing significance and the improvements they have brought. For a comprehensive overview of the advancements made in information systems, Table 2 in the research serves as a valuable reference, providing insights into their development and impact.

Table 1: Information Systems review

Era	**Systems**	**Description**
First Era	Manual Systems	During this era, supply chains relied on manual systems for data collection, processing, and communication. Sustainability considerations were limited, and information systems were primarily focused on basic inventory management and order processing. Tracking sustainability-related data and measuring supply chain impacts were challenging due to limited technological capabilities.
Second Era	Enterprise Resource Planning (ERP) Systems	With the advent of ERP systems, businesses gained the ability to integrate various functions and departments, resulting in improved visibility and control over supply chain processes. ERP systems allow for better inventory management, resource allocation, and coordination. While sustainability considerations were not the primary focus, ERP systems provided a foundation for capturing data that could be used for later sustainability analysis.
Third Era	Supply Chain Management (SCM) Systems	During this era, SCM systems emerged to address the complexities of supply chain operations. These systems provided enhanced functionality, including demand forecasting, supplier management, logistics optimization, and real-time data sharing. SCM systems enabled improved sustainability by facilitating the integration of sustainability criteria into supplier selection, transportation planning, and inventory optimization processes.
Fourth Era	Sustainable Supply Chain Management (SSCM) Systems	Sustainability has become a more prominent concern for supply chains in recent years. As a result, SSCM systems have been developed to address sustainability challenges explicitly. These systems include carbon footprint tracking, life cycle assessment, supplier sustainability performance monitoring, and product traceability. SSCM systems enable organizations to measure and manage sustainability impacts across the supply chain, driving more sustainable decision-making
Fifth Era	Digital Transformation and IoT-enabled Systems	The current era is characterized by the rapid advancement of digital technologies and the Internet of Things (IoT). These technologies enable real-time data collection, connectivity, and analysis, offering significant opportunities for supply chain sustainability. IoT-enabled systems can track and monitor environmental factors, energy usage, waste generation, and social impacts in real time. Advanced analytics and AI-driven algorithms help identify opportunities for sustainability improvements and optimize supply chain operations accordingly.

Information systems have been crucial in driving supply chain sustainability in each era. From basic data management to advanced sustainability-focused systems, information systems have evolved to support organizations in addressing sustainability's environmental, social, and economic aspects throughout the supply chain. These systems provide the foundation for data-driven decision-making, transparency, collaboration, and continuous supply chain sustainability performance improvement.

Below are fourteen information systems that play critical roles in modern organizations. They support various functions and improve operational efficiency, decision-making, and customer satisfaction.

1. Material Requirements Planning (MRP): MRP is an information system that manages and controls a manufacturing organization's inventory and production processes. It helps determine the quantity and timing of materials required for production, ensuring efficient resource allocation.
2. Manufacturing Resource Planning (MRP II): MRPII is an extension of MRP that integrates additional functions such as capacity planning, shop floor control, and financial management. It provides a comprehensive view of the manufacturing process, enabling effective planning and scheduling.
3. Enterprise Resource Planning (ERP): ERP systems integrate various business functions, including finance, human resources, supply chain management, customer relationship management, and manufacturing. They provide a centralized database and facilitate seamless information flow across different departments, improving operational efficiency and decision-making.

4. Warehouse Management System (WMS): WMS is an information system that manages and controls warehouse operations. It includes inventory management, order fulfillment, receiving and shipping, and warehouse optimization. WMS enables organizations to manage their inventory and streamline warehouse processes effectively.
5. Supply Chain Management (SCM): SCM systems facilitate the coordination and optimization of all activities involved in the supply chain, from raw material procurement to product delivery. It involves managing suppliers, logistics, inventory, and demand forecasting to ensure smooth operations and customer satisfaction.
6. Customer Relationship Management (CRM): CRM systems help organizations manage customer interactions, track customer information, and improve customer satisfaction. It includes sales management, marketing automation, customer support, and analytics functions to enhance customer relationships and drive business growth.
7. Supplier Relationship Management (SRM): SRM systems focus on managing supplier relationships. They streamline procurement processes, supplier selection, contract management, and performance evaluation to ensure a reliable and efficient supply chain.
8. Advanced Planning and Scheduling (APS): APS systems use algorithms and optimization techniques to create detailed production plans and schedules. They consider various factors such as resource availability, demand forecast, and production constraints to optimize production efficiency and meet customer demands.
9. Just-in-Time (JIT): JIT is an inventory management system aimed at minimizing inventory holding costs by receiving materials and producing goods only when needed. JIT relies on accurate demand forecasting, efficient supply chain coordination, and timely production to reduce waste and improve efficiency.
10. E-commerce: E-commerce refers to the buying and selling goods and services online. E-commerce systems enable businesses to conduct online transactions, manage storefronts, process payments, and provide customer support, allowing for global reach and 24/7 availability.
11. E-business: E-business encompasses a broader concept than e-commerce. It refers to using electronic technology to conduct and automate various business processes, including sales, marketing, procurement, supply chain management, and customer service.
12. Decision Support Systems (DSS): DSS systems provide interactive tools and models to assist managers in making informed decisions. They utilize data analysis, simulation, and visualization techniques to analyze complex problems, evaluate different scenarios, and support strategic decision-making.
13. Radio Frequency Identification (RFID): RFID systems use radio frequency technology to identify and track objects or people. They consist of tags that store and transmit data and readers that capture and process the information. RFID systems are widely used in inventory management, asset tracking, and access control applications.
14. Electronic Data Interchange (EDI): EDI enables the electronic exchange of business documents, such as purchase orders, invoices, and shipping notifications, between different organizations. It eliminates the need for manual data entry, reduces paperwork, and improves the speed and accuracy of information exchange.

In shape 1, another minimalist interpretation of sustainability relates to limitations. While trade-offs between sustainability pillars exist, incorporating sustainability measures into business activities does not necessarily limit firms. Sustainability can be a business driver rather than a cost center. Proactive sustainability strategies can lead to competitive advantages, cost savings, increased market share, and a stronger brand image. A socially and environmentally responsible supply chain is increasingly expected by stakeholders, making the triple-bottom-line approach essential for doing business in the twenty-first century [29].

2.2 Supply chain sustainability

Supply chain sustainability integrates environmental, social, and economic considerations into supply chain management practices. It involves managing the entire lifecycle of products or services, from sourcing raw materials to manufacturing, distribution, and disposal. Supply chain sustainability minimizes negative environmental and social impacts while maximizing economic value.

Integrating sustainability into business practices is a prominent research topic in supply chain management. While the term "sustainable" dates back to the 18th century, its significance increased with the publication of the Brundtland Report in 1987. The report defined sustainability as development that meets present needs without compromising future generations' ability to meet their needs. This definition emphasizes the balance between needs and limitations, which is crucial in sustainability [29].

Organizations need to consider various factors to achieve supply chain sustainability. These include reducing carbon emissions, conserving resources, promoting fair labor practices, ensuring ethical sourcing, supporting local communities, and fostering transparency and accountability throughout the supply chain.

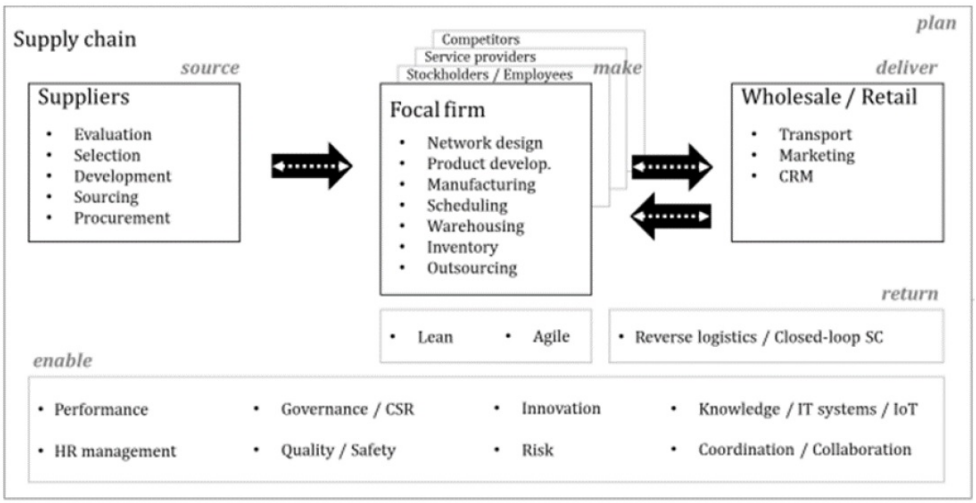

Figure 1: Information Systems play critical roles in modern organizations.

Implementing sustainable practices in the supply chain offers several benefits. Improved efficiency, reduced waste, and better risk management can save costs. It enhances brand reputation, attracts environmentally and socially conscious consumers, and can create new business opportunities. Additionally, it helps organizations comply with regulations, meet stakeholder expectations, and contribute to the planet's and society's overall well-being.

Collaboration and cooperation among all stakeholders are essential to achieve supply chain sustainability. This includes suppliers, manufacturers, distributors, retailers, customers, government bodies, and non-governmental organizations. By working together, organizations can establish sustainable sourcing strategies, implement environmentally friendly production processes, promote responsible consumption, and ensure the responsible disposal or recycling of products.

In summary, supply chain sustainability is about considering environmental, social, and economic factors throughout the supply chain to create long-term value while minimizing negative impacts. It is a holistic approach that requires collaboration, innovation, and ongoing commitment to create a more sustainable future for businesses, communities, and the planet.

By [6], a supply chain is defined as a network of parties fulfilling customer orders. Over the past decade, increasing customer demands and government regulations have compelled companies to reduce the environmental impacts of their products and processes [31]. The supply chain and sustainability interaction has become critical to operations and the environment. In the European Union, member states have made a collective effort to implement legislation that holds manufacturers accountable for waste collection, recycling, and safe disposal [7].

In [4], Carter and Roger put forth a comprehensive definition of Sustainable Supply Chain Management (SSCM) as the strategic and transparent integration of an organization's social, environmental, and economic goals in coordinating key inter-organizational processes. The aim is to enhance the long-term economic performance of the individual company and its supply chains. Seuring and Muller [35] have also recognized the diverse interpretations of sustainability within supply chain management, emphasizing the importance of the triple-bottom-line approach. This approach requires achieving a minimum level of performance across the environmental, economic, and social dimensions [38].

Integrating sustainability principles in supply chain management is increasingly crucial for long-term success. Organizations recognize the need to balance economic growth with environmental stewardship and social responsibility. This entails considering the entire lifecycle of products, from sourcing raw materials to disposal and collaborating with suppliers, manufacturers, and other stakeholders to implement sustainable practices. Companies can minimize environmental impacts, enhance social well-being, and drive economic value by adopting a holistic approach to supply chain sustainability.

In summary, supply chain sustainability involves the integration of environmental, economic, and social goals within supply chain management processes. It requires collaboration, transparency, and a commitment to achieving sustainable outcomes across all dimensions. As customer expectations and regulatory requirements evolve, organizations must proactively embrace sustainable practices to ensure their long-term viability and contribute to a more sustainable future [34, 49].

The Triple Bottom Line (TBL) approach encompasses three main aspects: environmental, economic, and social dimensions. These aspects collectively evaluate an organization's or supply chain's overall sustainability performance. Here's a breakdown of each aspect:

- Environmental Dimension: The environmental aspect focuses on assessing and managing the impact of business operations on the natural environment. It involves minimizing resource consumption, reducing waste generation, mitigating pollution, and adopting sustainable practices. Organizations strive to minimize carbon footprint, conserve energy, protect biodiversity, and promote eco-friendly initiatives.
- Economic Dimension: The economic aspect pertains to an organization's financial viability and economic performance. It involves analyzing the financial aspects of sustainable practices and assessing the economic benefits and costs associated with implementing sustainability initiatives. This includes evaluating sustainable actions' profitability, cost-effectiveness, and return on investment.
- Social Dimension: The social aspect involves considering the impact of business activities on people and society. It includes labor rights, human rights, employee well-being, community engagement, and stakeholder relationships. Organizations promote fair and ethical practices, ensure safe working conditions, respect human rights, foster diversity and inclusion, support local communities, and address social issues.

The TBL approach recognizes that sustainable success goes beyond financial gains and incorporates environmental and social responsibilities. It emphasizes the interconnectedness of these three dimensions, understanding that neglecting any aspect can harm long-term performance. By integrating environmental, economic, and social considerations, organizations can strive for a more comprehensive and balanced approach to sustainability [33, 42, 46].

Overall, the TBL approach encourages organizations to assess their financial profits, environmental preservation, and social well-being performance. It aims to create a harmonious relationship between business operations, the environment, and society, ultimately leading to sustainable development and a more equitable future. The factors or dimensions of the Triple Bottom Line (TBL) approach, which collectively evaluates the sustainability performance of an organization or a supply chain, are as follows [36, 37]:

1. Environmental Factor: This dimension focuses on the environmental impact of business operations and includes factors such as:
    - Resource conservation
    - Waste management and reduction
    - Pollution control and prevention
    - Energy efficiency
    - Carbon footprint reduction
    - Biodiversity conservation
2. Economic Factor: This dimension pertains to the financial viability and economic performance of the organization and includes factors such as:
    - Profitability
    - Cost-effectiveness
    - Return on investment
    - Financial stability
    - Economic growth
    - Market competitiveness
3. Social Factor: This dimension considers the impact of business activities on people and society and includes factors such as:
    - Labor rights and fair employment practices
    - Human rights
    - Employee well-being and safety
    - Community engagement and development

- Stakeholder relationships and engagement
- Social equity and inclusion

These three factors together represent the triple bottom line, with each dimension reflecting a different aspect of sustainability. By considering and balancing the environmental, economic, and social factors, organizations can strive for holistic sustainability and long-term success. It is important to note that specific factors and their prioritization may vary depending on the industry, organization, and stakeholder expectations [2, 3, 32, 44, 47, 48].

3 Research methodology

In this research, the VIKOR technique is employed to analyze the main indicators of a sustainable supply chain in the context of the Telecom industry. The selection of MSC is based on its prominence as the largest steel producer in the Middle East and Northern Africa region and its extensive experience with information systems like ERP, CRM, and DSS. Additionally, MSC's commitment to environmental sustainability, demonstrated by obtaining ISO 14000 certification and implementing various environmental projects, makes it an ideal case for examining the impact of information systems on supply chain sustainability [41].

The research methodology comprises the following steps [11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24]:

1. Literature Review:
   - Conduct a comprehensive review of relevant literature to identify the main indicators of a sustainable supply chain.
   - Present the identified indicators in Table 4, which serves as a reference for the analysis.
2. Expert Consultation:
   - Consult with experts from the telecom industry in Iran to gather insights and validate the identified indicators.
   - Categorize the indicators based on expert inputs to facilitate the analysis process.
3. VIKOR Technique:
   - Apply the VIKOR technique to analyze the categorized indicators.
   - Assign weights to each indicator based on their relative importance in achieving supply chain sustainability.
   - Evaluate each indicator against predefined criteria, considering environmental, social, and economic aspects.
   - Calculate the VIKOR score for each indicator, representing its ranking in terms of its impact on supply chain sustainability.
4. Data Analysis:
   - Analyze the results obtained from the VIKOR technique to determine the ranking of the indicators.
   - Interpret the findings and identify the top-ranked indicators contributing to supply chain sustainability.

Utilizing the VIKOR technique, this research aims to provide valuable insights into the effective factors of information systems on supply chain sustainability in the telecom industry, specifically within the Telecom Industry of Iran. The findings of this study will contribute to the existing knowledge on sustainable supply chains and offer practical recommendations for MSC and other steel companies to enhance their supply chain sustainability practices.

Step 1: Formulate the Decision Matrix

The decision matrix is constructed as follows, based on the number of criteria, alternatives, and evaluations of each alternative for different criteria.

$$X = \begin{matrix} C_1 & \cdots & C_n \end{matrix} \\ \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \tag{3.1}$$

where x_{ij} The score of the alternative i $(i = 1, ..., m)$ is related to the criterion j $(j = 1, ..., n)$.

Step 2. Establish the Normalized Decision Matrix

In this stage, employing established techniques, the decision matrix is normalized. Specifically, all cost criteria are transformed into benefit criteria to ensure uniform treatment of all criteria by the VIKOR method.

$$\begin{cases} n_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, & i = 1, ..., m;\ j \in \text{Benfit Set} \\ n_{ij} = \frac{\frac{1}{x_{ij}}}{\sum_{i=1}^{m} \frac{1}{x_{ij}}}, & i = 1, ..., m;\ j \in \text{Cost Set} \end{cases} \tag{3.2}$$

$$N = \begin{bmatrix} n_{11} & \cdots & n_{1n} \\ \vdots & \ddots & \vdots \\ n_{m1} & \cdots & n_{mn} \end{bmatrix} \tag{3.3}$$

Step 3. Assigning Weights to Criteria

During this stage, the weight vector for the criteria is determined based on their respective importance in the decision-making process, following the principles of the VIKOR method. As $w_j (j = 1, ..., n)$.

$$W = [w_1, w_2, ..., w_n] \tag{3.4}$$

Step 4. Identify the Optimal and Pessimistic Values for Each Criterion

In this phase, considering converting all criteria into profit-oriented measures in the previous step, only the best values are determined for profit indicators. However, if an alternative normalization method is employed, the optimal and pessimistic values should also be determined for cost indicators as part of this step.

$$\begin{aligned} f_j^* &= \max_{i=1,...,m} \{n_{ij}\} \qquad j = 1, ..., n \\ f_j^- &= \min_{i=1,...,m} \{n_{ij}\} \qquad j = 1, ..., n \end{aligned} \tag{3.5}$$

Step 5. Calculating the Distance between Best and Worst Scenarios

During this step, the distance between the best and worst situations is determined for each criterion. This calculation helps quantify the range of variation within each criterion and plays a vital role in the VIKOR decision-making process.

The distance to the best situation (utility measure is in S_i $(i = 1, ..., m)$, And the distance to the worst situation (reject measure) is shown as $R_i (i = 1, ..., m)$.

$$value\ S_i = \sum_{j=1}^{n} w_j \left(\frac{|f_j^* - n_{ij}|}{|f_j^* - f_j^-|} \right), \quad i = 1, ..., m \tag{3.6}$$

$$R_i = \max_{j=1,...,n} \left\{ w_j \left(\frac{|f_j^* - n_{ij}|}{|f_j^* - f_j^-|} \right) \right\}, \quad i = 1, ..., m \tag{3.7}$$

Step 6. Calculating the Q Index

In this step, the Q index is computed by combining the convex combination of the two distances, S and R, calculated in the previous step. The Q index serves as a comprehensive measure that considers both the L-1 and L-distances to assess each alternative's overall performance in the VIKOR decision-making process.

$$Q_i = \nu \left(\frac{S_i - S^*}{S^- - S^*} \right) + (1 + \nu) \left(\frac{R_i - R^*}{R^- - R^*} \right), \quad i = 1, ..., m \tag{3.8}$$

$$S^* = \min_{i=1,...,m} \{S_i\},\ S^- = \max_{i=1,...,m} \{S_i\},\ R^* = \min_{i=1,...,m} \{R_i\},\ R^- = \max_{i=1,...,m} \{R_i\}. \tag{3.9}$$

Step 7. Rank the alternatives.

The alternatives are ranked using the R, S, and Q ranking systems. Consequently, three ranking lists are generated, with lower values indicating superior alternatives.

In the ranking based on the Q index, the top-ranked alternative is selected if it satisfies the following conditions:

1. It has the lowest Q index value among all alternatives.

2. It possesses the shortest distance from the ideal solution, as represented by the R criterion.
3. It exhibits the smallest distance from the worst solution, as indicated by the S criterion.

Fulfilling these conditions, the top-ranked alternative is identified and considered the most favorable choice in the VIKOR decision-making process.

4 Results

Based on the expertise of industry professionals in the telecommunications sector and the adjustment of weights for the indices in the VIKOR technique, the indices related to the subject of this study have been ranked as follows. However, it should be noted that this ranking is based on the opinions of a five-member group of telecommunications industry experts in Iran and may vary in other companies.

Table 2: The rank of sub-factors

Sub-Factors	**Rank**	**TBl-line**
Resource conservation	10	Environmental Factor
Waste management and reduction	16	
Pollution control and prevention	17	
Energy efficiency	15	
Carbon footprint reduction	18	
Biodiversity conservation	11	
Profitability	5	Economic Factor
Cost-effectiveness	6	
Return on investment	1	
Financial stability	2	
Economic growth	3	
Market competitiveness	4	
Labor rights and fair employment practices	12	Social Factor
Human rights	8	
Employee well-being and safety	7	
Community engagement and development	13	
Stakeholder relationships and engagement	9	
Social equity and inclusion	14	

5 Conclusion

This paper aims to analyze the relationships between information systems and supply chain sustainability. Thirty-two information systems experts and managers were selected to investigate these relationships, and data was collected through professional interviews. Applying the VIKOR technique, the analysis revealed that the third group of information systems, namely E-Business, E-Commerce, and Just-in-Time, had the most significant impact on supply chain sustainability. RFID, EDI, and barcoding systems followed closely in second place, while ERP, MRP, and MRP II systems were identified as the next most effective information systems. Economic factors such as Profitability, Cost-effectiveness, return on investment, financial stability, Economic growth, and Market competitiveness were found to be the most influential factors affecting sustainable supply chain practices. It is crucial to focus on E-Business and technological systems like RFID and EDI to establish a sustainable supply chain through the implementation of information systems. Notably, the most significant effects of these applications were observed in the company's economic and organizational aspects, satisfying top managers and stakeholders. The initial step towards implementation involves providing adequate software and hardware infrastructures, along with comprehensive staff training. As this research marks the first exploration in this specific area, further studies in different contexts would provide better insights into the relationships between information systems and supply chain sustainability. Additionally, it is beneficial to investigate alternative methods for analyzing the applications of information systems in the context of sustainable supply chain management.

References

[1] P. Ahi and C. Searcy, *A comparative literature analysis of definitions for green and sustainable supply chain management*, J. Clean. Prod. **52** (2013), 329–341.

[2] C. Bai and J. Sarkis, *A supply chain transparency and sustainability technology appraisal model for blockchain technology*, Int. J. Prod. Res. **58** (2020), no. 7, 2142–2162.

[3] M. Basheer, M. Siam, A. Awn, and S. Hassan, *Exploring the role of TQM and supply chain practices for firm supply performance in the presence of information technology capabilities and supply chain technology adoption: A case of textile firms in Pakistan*, Uncertain Supply Chain Manag. **7** (2019), no. 2, 275–288.

[4] C.R. Carter and D.S. Rogers, *A framework of sustainable supply chain management: Moving toward new theory*, Int. J. Phys. Distrib. Logistics Manag. **38** (2008), no. 5, 360–387.

[5] I.J. Chen and A. Paulraj, *Understanding supply chain management: Critical research and a theoretical framework*, Int. J. Prod. Res. **42** (2004), no. 1, 131–163.

[6] S. Chopra and P. Meindl, *Supply Chain Management: Strategy, Planning, and Operation*, Pearson Prentice Hall, 2007.

[7] M.J. Eskandari, M. Miri, M. Shirani and H.S. Sangchouli, *Sustainable supply chain management and logistics*, Manag. Admin. Sci. Rev. **3** (2014), no. 4, 665–667.

[8] K. Ferdows and A. De Meyer, *Lasting improvements in manufacturing performance: in search of a new theory*, J. Oper. Manag. **9** (1990), no. 2, 168–184.

[9] A. Gunasekaran, N. Subramanian, and T. Papadopoulos, *Information technology for competitive advantage within logistics and supply chains: A review*, Transport. Res. Part E: Logistics Transport. Rev. **99** (2017), 14–33.

[10] E. Hassini, C. Surti, and C. Searcy, *A literature review and a case study of sustainable supply chains with a focus on metrics*, Int. J. Prod. Econ. **140** (2012), no. 1, 69–82.

[11] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi and S. Razipour GhalehJough, *Analytical hierarchy process (AHP) in guzzy environment*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Comput. Intell. Springer, Cham. **1121** (2023).

[12] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi and S. Razipour GhalehJough, *The criteria importance through inter-criteria correlation (CRITIC) in uncertainty environment*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Comput. Intell. Springer, Cham. **1121** (2023).

[13] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi and S. Razipour GhalehJough, *Foundations of decision*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Comput. Intell. Springer, Cham. **1121** (2023).

[14] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi and S. Razipour GhalehJough, *The multi-objective optimization ratio analysis (MOORA) in uncertainty environment*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Comput. Intell. Springer, Cham. **1121** (2023).

[15] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi and S. Razipour GhalehJough, *The measuring attractiveness by a categorical based evaluation technique (MACBETH) in uncertainty environment*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Comput. Intell. Springer, Cham. **1121** (2023).

[16] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi, and S. Razipour GhalehJough, *Weight determination methods in fuzzy environment*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Comput. Intell. Springer, Cham. **1121** (2023).

[17] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi, and S. Razipour GhalehJough, *Technique for order preferences by similarity to ideal solutions (TOPSIS) in uncertainty environment*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Computational Intell. Springer, Cham. **1121** (2023).

[18] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi, and S. Razipour GhalehJough, *Fuzzy introductory concepts*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Comput. Intell. Springer, Cham. **1121** (2023).

[19] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi, and S. Razipour GhalehJough, *Simple additive weighting (SAW) method in fuzzy environment*, Fuzzy decision analysis: multi attribute decision

making approach, Stud. Comput. Intell. Springer, Cham. **1121** (2023).

[20] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi, and S. Razipour GhalehJough, *Elimination choice translating reality (ELECTRE) in uncertainty environment*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Comput. Intell. Springer, Cham. **1121** (2023).

[21] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi, and S. Razipour GhalehJough, *Multi attributive border approximation area comparison (MABAC) in uncertainty environment*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Comput. Intell. Springer, Cham. **1121** (2023).

[22] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi, and S. Razipour GhalehJough, *The complex proportional assessment (COPRAS) in uncertainty environment*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Comput. Intell. Springer, Cham. **1121** (2023).

[23] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi, and S. Razipour GhalehJough, *VIKOR method in uncertainty environment*, In: Fuzzy decision analysis: multi attribute decision making approach, Stud. Computational Intell. Springer, Cham. **1121** (2023).

[24] F. Hosseinzadeh Lotfi, T. Allahviranloo, W. Pedrycz, M. Shahriari, H. Sharafi, and S. Razipour GhalehJough, *Non-compensatory methods in uncertainty environment*, Fuzzy decision analysis: multi attribute decision making approach, Stud. Computational Intell. Springer, Cham. **1121** (2023).

[25] P.H. Ketikidis, S.C.L. Koh, N. Dimitriadis, A. Gunasekaran, and M. Kehajova, *The use of information systems for logistics and supply chain management in South East Europe: Current status and future direction*, Omega **36** (2008), no. 4, 592–599.

[26] P. Kumar, *Information technology: Roles, advantages and disadvantages*, Int. J. Adv. Res. Comput. Sci. Software Eng. **4** (2014), no. 6, 1020–1024.

[27] C. Li, Y. Xu, and H. Li, *An empirical study of dynamic customer relationship management*, J. Retail. Consum. Serv. **12** (2005), no. 6, 431–441.

[28] H. Mahmoudi, M. Sharifi, M.R. Shahriari, and M.A. Shafiee, *Solving a reverse logistic model for multilevel supply chain using genetic algorithm*, Int. J. Ind. Math. **12** (2020), no. 2, 177–188.

[29] C.L. Martins and M.V. Pato, *Supply chain sustainability: A tertiary literature review*, J. Clean. Prod. **225** (2019), 995–1016.

[30] V. Mohagheghi, S.M. Mousavi, B. Vahdani, and M.R. Shahriari, *R&D project evaluation and project portfolio selection by a new interval type-2 fuzzy optimization approach*, Neural Comput. Appl. **28** (2017), 3869–3888.

[31] R.K. Mudgal, R. Shankar, P. Talib, and T. Raj, *Modelling the barriers of green supply chain practices: an Indian perspective*, Int. J. Logistics Syst. Manag. **7** (2010), no. 1, 81–107.

[32] M.A. Nayebi, M. Sharifi, M.R. Shahriari, and O. Zarabadipour, *Fuzzy-chance constrained multi-objective programming applications for inventory control model*, Appl. Math. Sci. **6** (2012), no. 5, 209–228.

[33] A. Resolution, *RES/70/1. Transforming our world: the 2030 agenda for sustainable development*, Seventieth United Nations General Assembly, New York, Vol. 25, 2015, pp. 86–97.

[34] J. Sarkis, Q. Zhu and K.-H. Lai, *An organizational theoretic review of green supply chain management literature*, Int. J. Prod. Econ. **130** (2011), no. 1, 1–15.

[35] S. Seuring, J. Sarkis, M. Müller, and P. Rao, *Sustainability and supply chain management–an introduction to the special issue*, J. Clean. Prod. **16** (2008), no. 15, 1545–1551.

[36] M. Shahriari, *Malmquist productivity index for two-stage structures and its applications in bank branches*, Int. J. Ind. Math. **3** (2011), no. 4, 325–335.

[37] M. Shahriari, *Ranking network-structured decision-making units and its application in bank branches*, Int. J. Ind. Math. **5** (2013), no. 4, 397–402.

[38] M.R. Shahriari, *Soft computing based on a modified MCDM approach under intuitionistic fuzzy sets*, Iran. J. Fuzzy Syst. **14** (2017), no. 1, 23–41.

[39] M.R. Shahriari, *Enterprise resource planning selection based on a preference voting and data envelopment analysis*,

Int. J. Data Env. Anal. **9** (2021), no. 3, 55–64.

[40] M. Shahriari, A. Hajiha and S. Dehghan, *A behavioral loyalty model of portable computers' users*, IEEE Int. Conf. Ind. Engin. Engin. Manag., IEEE, 2014, pp. 259–263.

[41] M.R. Shahriari and N. Pilevari, *Agile supplier selection in sanitation supply chain using fuzzy VIKOR method*, J. Optim. Industr. Eng. **10** (2016), no. 21, 19–28.

[42] M.R. Shahriari, N. Pilevari, and Z. Gholami, *The effect of information systems on the supply chain sustainability using DEMATEL method*, Commun. Adv. Comput. Sci. Appl.**1** (2016), 47–56.

[43] A.A. Shaikh and H. Karjaluoto, *Making the most of information technology and systems usage: A literature review, framework and future research agenda*, Comput. Human Behav. **49** (2015), 541–566.

[44] K.T. Shibin, R. Dubey, A. Gunasekaran, B. Hazen, D. Roubaud, S. Gupta, and C. Foropon, *Examining sustainable supply chain management of SMEs using resource based view and institutional theory*, Annal. Oper. Res. **290** (2020), 301–326.

[45] D. Simchi-Levi, P. Kaminsky, and E. Simchi-Levi, *Designing and Managing the Supply Chain: Concepts, Strategies, and Cases*, New York, McGraw-Hill, 1999.

[46] S.A. Yawar and S. Seuring, *Management of social issues in supply chains: A literature review exploring social issues, actions, and performance outcomes*, J. Bus. Ethics **141** (2017), no.3, 621–643.

[47] A. Zaretalab, V. Hajipour, M. Sharifi and M.R. Shahriari, *A knowledge-based archive multi-objective simulated annealing algorithm to optimize series–parallel system with choice of redundancy strategies*, Comput. Ind. Eng. **80** (2015), 33–44.

[48] H. Zeraati, L. Rajabion, H. Molavi, and N.J. Navimipour, *A model for examining the effect of knowledge sharing and new IT-based technologies on the success of the supply chain management systems*, Kybernetes **49** (2020), no. 2, 229–251.

[49] M. Zorzini, L.C. Hendry, F.A. Huq, and M. Stevenson, *Socially responsible sourcing, Reviewing the literature and its use of theory*, Int. J. Oper. Prod. Manag. **35** (2015), no. 1, 60–109.