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Supply chain digitalization: An integrated MCDM approach for inter-organizational information systems selection in an electronic supply chain

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ABSTRACT

Efficient Inter-Organizational Information Systems (IOIS) have become the backbone of modern supply chains. IOIS can be used to plan, coordinate, collaborate and integrate supply chains for attaining competitive advantage. The speed of innovative technology evolvement, lack of clarity, and delay in taking appropriate managerial and strategic decisions for adopting IOIS demand further research in this area. The robust advancement in digital technologies stresses a proper decision model for the IOIS adoption process. This paper provides a novel model for selecting the best IOIS alternative by considering the contents, scope, and critical decision-making factors affecting supply chain integration. Twelve decision-making factors affecting IOIS selection were identified and categorized under four significant dimensions: technological, operational, application, and innovative for effective decision-making. Study results reveal that project completion time is the most relevant criterion, followed by digital technology enablers and the financial resources required to select IOIS alternatives.

1. Introduction

The efficient use of Inter-Organizational Information Systems (IOIS) by firms assists in gaining a competitive advantage in the dynamic business environment. IOIS is a value-added shared information system among businesses facilitating generating, converting, storing, and communicating information, resulting in enhanced capabilities. In recent years, the digital transformation of the SC by using IOIS has gained greater significance. Hence, the managers should manage and deploy IOIS to improve Supply Chain (SC) capabilities and performance (Asamoah, Agyei-Owusu, Andoh-Baidoo & Ayaburi, 2021). IOIS implementation process in an organization is a challenging task due to the involvement of multiple participants, diverse cultures, strategies, and interests. The adaptability of IOIS with the existing information systems is one of the significant aspects to be considered while integrating the SC digitally. The effective utilization of technological advancement in the SC depends upon the selection of appropriate IOIS solutions. Thus, developing and implementing a decision model that could assist managers in effective decision-making will be relevant in the digital era.

IOIS has emerged as one of the dominant topics in SC due to innovations in digital technologies. The significance of information technology (IT) in integrating SC is widely addressed in the literature (Naway & Rahmat, 2019; Sutduean, Joemsittiprasert & Jermsittiparsert, 2019). IOIS facilitates interconnection between enterprise information systems using information and communication technology tools. Effective SC integration using IOIS enables timely access to information required for forecasting, production planning, scheduling and collaborative planning. IOIS can also be adopted to gain economies of scale, reduce risks, increase competitiveness, overcome investment barriers, and better communication to reap the benefits (Kakhki & Gargeya, 2019).

Information systems adoption has emerged as the core aspect to be considered in the technology revolution. Implementing information systems in an organization should be regarded as a strategic discipline (Jeffree et al., 2020). IOIS can strengthen collaborative planning, SC visibility, logistics, vendor-managed inventory, forecasting, and replenishment. IOIS enables developing a technology culture in the organization to gain competitive advantage and practical application of information systems tools (Jayakrishnan, Mohamad & Abdullah, 2019). Cichosz, Wallenburg & Knemeyer (2020) has mentioned the allocation of resources in exploiting advanced digital technologies resulting in the transformation of organizations.

The application of information systems by organizations is of greater significance in achieving efficiency through cognitive computing. Hence, addressing the issues faced during the analytics of big data and the need for further exploration of the parameters which affect cognitive computing is gaining relevance (Gupta, Kar, Baabdullah & Al-Khowaiter, 2018).

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The uncertainties and dynamics of SC in the era of Industry 4.0 and the evaluation of SC performance are also highlighted in the literature (Han, Hou, Bi, Yang & Zheng, 2021). In a digitized SC, companies use various software platforms to collaborate and drive SC activities. Major software platforms available in the market include Oracle, E2open, Manhattan, Epicor Dassault Systems, Logility, Descartes, etc. The selection of software platforms and their associated digital solutions varies among firms as it depends mainly on the nature of business activities. The challenges faced while developing solutions for the digitalization of SCs in a dynamic business environment finds mentioned in the literature. Vast advancements in digital and Internet-enabled innovative technologies demand more research in SC networks (Kakhki & Gargeya, 2019). The existing literature lacks research on Supply Chain Digitalization (SCD) using IOIS and its integration. Literature also reveals that even though there are papers on digitalization, a model for SC integration using IOIS is rarely found.

In this research, we are trying to address this gap by developing a model for decision-making to select suitable IOIS solutions for digitalization. Various types of risks influence the decision-making for SCD. It involves considering both qualitative and quantitative criteria, making it challenging for the SC managers. The model for SC integration proposed in this paper aims to bring flexibility, capability, adaptability and quick response to SC processes. This study tries to address the knowledge gap in the procedure by developing a suitable model for SCD by adopting IOIS. The main objectives of the research are as follows:

(i) To develop a model for SCD by adopting IOIS.
(ii) To identify the key decision-making factors (DMFs) to be considered for selecting IOIS solutions.
(iii) To check the robustness of the model through case evaluation using a hybrid AHP-TOPSIS method.

This study considers various key decision-making factors and dimensions facilitating the digitalization process. Also, it contributes to the theory of digitalization of SC, its integration, and methodologies to be used for selecting suitable IOIS solutions. In this study, the key DMFs affecting the selection of IOIS were initially identified, followed by developing a model for IOIS selection. Further, the robustness of the model is verified by applying it in a case electronics company. The electronics industry is one of the most dynamic industries, fast-changing with the rise in technological innovations. Different challenges the electronics industry face include technological advancements, shorter product life cycles (Huang, Romero, Osterman, Das & Pecht, 2019), decreasing operating margins, uncertain demand and supply, outsourcing, warranty and service issues, outsourcing, etc. The digitalization of SC helps address the challenges faced by the electronics industry to some extent using IOIS. While designing and planning the SC, electronics manufacturers must also consider content delivery and physical SC due to advancements in technology. Thus, digital assets and digital rights management become crucial aspects while adopting appropriate IOIS systems.

The model comprises applying Analytical Hierarchical Process (AHP) integrated TOPSIS method to analyze and select suitable IOIS alternatives. Key DMFs influencing the SC while digitalizing using IOIS are also analyzed. The weights of DMFs are determined using the AHP method. Finally, the weights obtained for the DMFs are used in the TOPSIS method, which considers the best and worst deals while evaluating the IOIS alternatives. Therefore, the key contribution of this study is identifying the DMFs affecting the selection of IOIS solutions and developing an integrated MCDM approach for selecting the most appropriate IOIS solution.

Further, an Indian electronics SC is considered in validating the model suggested for selecting the most appropriate IOIS solution. Considering these aspects, the electronics manufacturers are developing new strategies in managing SC. The firm considered in this study would like to proceed with SCD using IOIS solutions. The main contributions of this research are as follows:

- Key DMFs influencing the selection of IOIS are identified and shortlisted.
- A model for selecting the most appropriate IOIS for SCD is developed.
- The model is validated through a case study using AHP integrated TOPSIS methodology.
- Addresses significant concerns for IOIS adoption and assists practicing managers and policymakers in framing strategies for digitalization.

This paper is further organized as follows. Section 2 deals with a literature review on the subject. The research methodology is detailed in Section 3. The decision model for IOIS integration of the SC is given in Section 4. The application of the model in a case company, along with the results, is detailed in Section 5. Discussions, theoretical & managerial implications, limitations and future scope of research are mentioned in Section 6, followed by conclusions of the study in Section 7.

2. Literature review

This section deals with the literature review on digitalization of SC and Inter-Organizational Information Systems in the SC, followed by problem description and gaps in the literature in separate sub-sections.

2.1. Digitalization of supply chain

The strategic adoption of digital technologies by firms is gaining relevance. A digital SC network is an interconnected network that facilitates the continuous flow of information and automation among SC partners. The digitalization process will create value and capture opportunities through real-time data access and data analytics (Hakanen & Rajala, 2018).

In their study, Grover, Kar & Dwivedi (2020) addressed the application of artificial intelligence in operations management like product development, manufacturing, SC, and services. The application of digital technologies results in the generation of data inputs which facilitates effective control and planning by reducing cost and attaining environmental sustainability (Salgado, 2021). Gu, Yang & Huo (2021) studied the implications of the performance of information technology with partners in achieving SC resilience and found that the application of IT with customers and suppliers has a significant impact on SC resilience.

Yang, Fu & Zhang (2021b) have developed a framework for adopting digital technology mentioning the drivers, processes and impact, which assists in finalizing various strategies for digitalization. The five common mistakes that companies face while adopting digital technologies include (i) additional cost for the customer, (ii) privacy and security risks, (iii) threat from competitors with digitally advanced products and services, (iv) delay in switching over to digitization resulting in losing customers and (v) overestimation of the internal capabilities to proceed with digitalization (Porter & Heppelmann, 2015). Fig. 1 shows an integrated research framework for the digitalization of the SC using IOIS.

A framework for digital technologies must consider various hardware and software solutions that facilitate an integrated model for SCD. This framework would be helpful for organizations in identifying and planning activities for the digitalization of SCs. It involves various activities viz. (i) decision dimensions, (ii) selection process and (iii) its implementation. The use of advanced digital platforms helps in gaining significant opportunities (Lenka, Parida & Wincent, 2017). Intelligence capability, connect capability, and analytic capabilities are the three digitalization capabilities found in the literature. The impact of various approaches like circular business models, digital business transformation and organizational ambidexterity on Industry 4.0 and sustainable capabilities is also mentioned. It is found that digital business transformation mediates the relationship resulting in the integration of circular principles and devising business models (Belhadi, Kamble, Gunasekaran & Mani, 2021).

The role of big data analytics and its execution in SC management practices of the health care sector is found in the literature. Yu, Wong,

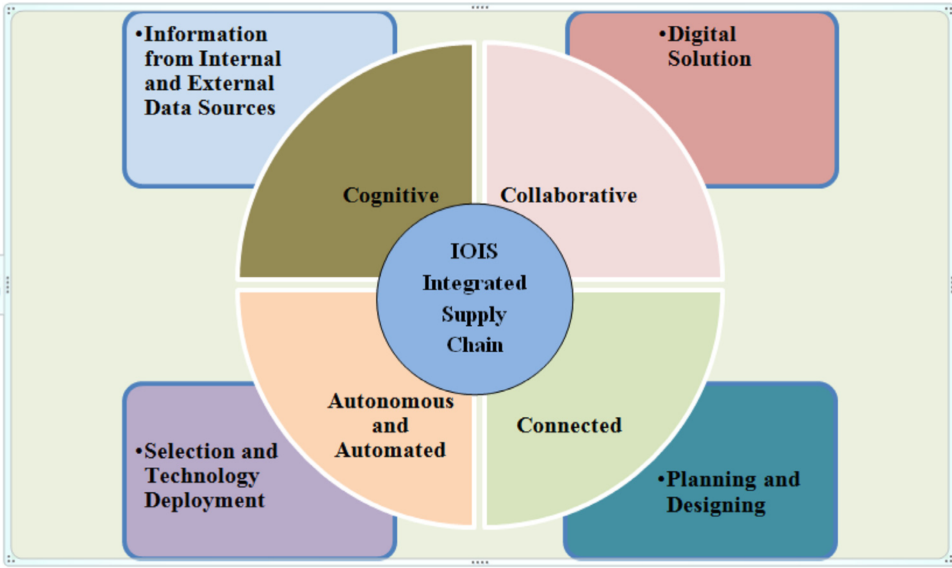

Fig. 1. A research framework for IOIS integrated supply chain.

Chavez & Jacobs (2021a) have addressed the capability of big data analytics and its application by integrating with hospital SC and flexibility in operations. Blockchain technology offers immutability and traceability of the transactions, resulting in a competitive advantage. (Werner, Basalla, Schneider, Hays, & VomBrocke, 2021) have investigated the impact of the adoption of blockchain technology on a firm's competitive performance from an inter-organizational perspective.

The Industry 4.0 initiatives and their progress in manufacturing firms can be tracked through maturity models and guide organizations in the digitalization process. Caiado et al. (2021) developed an Industry 4.0 maturity model based on fuzzy logic multi-method approach and validated it through an actual case application. Industry 4.0 is the key factor driving the development of smart cities. Sharma, Shanker & Barve (2021) have developed a framework for understanding SC 4.0 in smart city development.

Deepu & Ravi (2021) have built a conceptual framework for SCD using data, information, knowledge and wisdom hierarchy and developed a decision support system for proceeding effectively with digitalization. The digitalization process creates collaborative value across SC networks and their partners. SCs will become more productive by collecting, sharing, and processing information for effective decision-making. Cloud computing and blockchain are advanced digital technologies that provide data sharing on a real-time basis across the SC. In addition, 3D printing and reconfigurable manufacturing technologies reduce lead time and SC costs. Yang, Huo, Tian & Han (2021a) have studied and validated the role of digitalization in enhancing IOIS and technological activities in the SC. Literature reveals that the digitalization process gains competitive advantage and opportunities for a company, whereas its implementation is equally challenging. It is also found that the literature on the adoption of digital technologies in manufacturing firms at the SC level is minimal.

2.2. *Inter-organizational information systems in supply chain*

Literature reveals that IOIS is one of the critical factors that assist in maintaining inter-organizational relationships. Firms involved in integrating the SCs using IOIS can share technologies and exchange information on a real-time basis to facilitate decision-making (Haseeb, Hussain, Slusarczyk & Jermsittiparsert, 2019). SCs are rapidly transforming based on digital technologies (Ivanov, Dolgui & Sokolov, 2019). A high level of dynamism in the SC results in sharing information through integrated systems within and among the organizations. The central concept of inter-organizational relationships refers to trust, commitment and shared vision among SC partners. Enhancing the performance of SC for sustaining competitive advantage is one of the critical issues. The speed of information flows gets increased using advanced digital technologies (Moeuf, Pellerin, Lamouri, Tamayo-Giraldo & Barbaray, 2018). Accurate and real-time sharing of information among the SC partners helps in effective SC management.

Information sharing among SC partners is one of the critical components of the SC while adopting IOIS. It leads to better inter-organizational relationships and interfacing among organizations having a shared vision. Digital technologies can be classified into three major areas. The first one is the digital technology enabler which is the backbone of the digitization process and consists of big data, Internet of things (Moeuf et al., 2018) and cloud computing. The second one is the digital system integrator which consists of cyber-physical systems, simulations and artificial intelligence. The third area is application technologies, including additive manufacturing, 3D printing, human-machine integration, and autonomous machines and systems. Digital technologies help integrate data collected from various sources and facilitate timely production and distribution of goods and services. Further, applying these advanced technologies creates business value and higher revenue for firms (Buyukozkan & Gocer, 2018).

The nature and application of information systems can change the availability of data and its access across various SC partner's platforms. The impact of artificial intelligence and its future applications in the industry finds mentioned in the literature, duly recognizing the drastic development and application in the sector (Dwivedi et al., 2021). Implementing information systems facilitates artificial intelligence technology, which has a broad impact on the industries across various functions.

The adoption of IOIS results in extending the organizational boundaries. Asamoah et al. (2021) have found that efficient IOIS utilization and maximization of IOIS management capability in the organization are the essential requirements for better SC performance. Huo, Haq & Gu (2021) have studied the impact of information sharing on various SC stakeholders and its influence on flexibility performance. They also proposed a framework revealing the role of information sharing in enhancing SC learning and flexibility performance.

Big data analytics capability has a noticeable positive impact on SC finance integration and SC partners. Yu, Zhao, Liu & Song (2021b) proposed a theoretical framework investigating the impact of big data analytics capability in implementing SC finance. The planning and controlling of information based on informatics facilitate effective and efficient coordination among the stakeholders. The application of digital data and

Table 1
Literature on Inter-Organizational Information Systems in Supply Chain.

Sl. No	Area of Study	References	Relevance of Study
1	IT and organizational performance	Sutduean et al., 2019	Material and information flow in SC integration and its correlation with SC performance.
2	IT infrastructure and trade digitalization	Saengchai & Jermsittiparsert, 2019	Relationship between IT standardization, integration and SC performance.
3	Digital supply chain business models	Nurk, 2019	Capabilities of information systems in SC.
4	Green SC Management and Green Information System	Yang, Sun, Zhang & Wang, 2020	Studied the synergy between green SCM and green information systems.
5	Evolving information systems and technology research issues for COVID-19 and other pandemics	O'Leary, 2020	Issues concerning information systems and information technology researchers
6	Inter-organizational Information and communication technology	Zhang, van Donk & Jayaram, 2020	Information and communication technology implementation based on an inter-organizational perspective.
7	Information and digital technologies of Industry 4.0 and Lean supply chain management	Nunez-Merino, Maqueira-Marín, Moyano-Fuentes & Martínez-Jurado, 2020	Relationship between information and digital technologies of Industry 4.0 and lean SC Management
8	Blockchain Adoption from an Interorganizational Systems Perspective	(Werner, Basalla, Schneider, Hays, & VomBrocke, 2021)	Presented the impact of blockchain technology adoption from an inter-organizational systems perspective.
9	Agility in the humanitarian supply chain: an organizational information processing perspective and relational view.	Dubey, Bryde, Foropon, Graham, Giannakis & Mishra, 2020	Role of information sharing in SC visibility in enhancing agility in humanitarian SCs.
10	Supply chain information integration and its impact on the operational performance	Vafaei-Zadeh, Ramayah, Hanifah, Kurnia & Mahmud, 2020	Influence of SC information integration on the operational performance of manufacturing firms
11	Inter-organizational systems use and supply chain performance:	Asamoah et al., 2021	Mediating role of SC management capabilities.

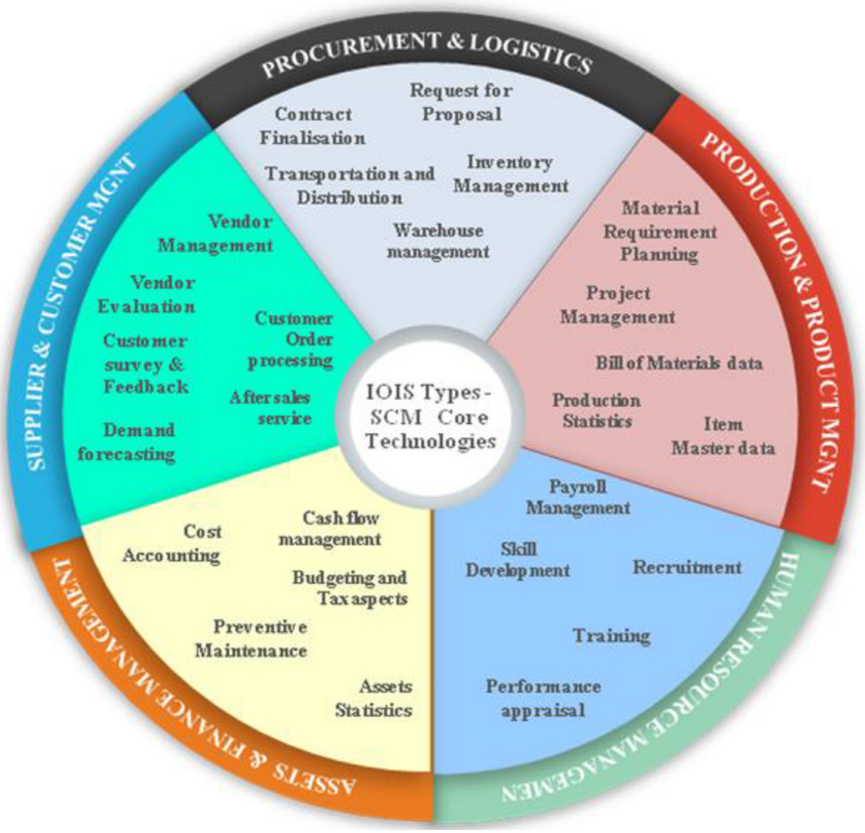

Fig. 2. Inter-organizational information system types and supply chain management core technologies.

sharing among the stakeholders make to respond effectively and quickly against changes in construction SC (Chen, Adey, Haas & Hall, 2021).

The dynamism of the SCs can be measured based on the introduction of new products and their revenue share, frequency of innovation for new products, and rate of operating processes for innovation. Information sharing, trust and collaboration are some of the key forms of inter-organizational competencies in a relationship-based SC (Abdallah, Abdullah & Mahmoud Saleh, 2017). Table 1 highlights the relevant literature on IOIS in the SC. A diagrammatic representation of various types of IOIS and core SC management technologies is shown in Fig. 2.

The application of IOIS facilitates enhancing its internal resources and assists in gaining competitive advantage and significant benefits (Asamoah, Agyei-Owusu, Andoh-Baidoo & Ayaburi, 2019). There is a need to investigate further the influence of IOIS in SC and its performance (Aydiner, Tatoglu, Bayraktar & Zaim, 2019). The role of customers in devising firms' inventory and inter-organizational limitations in SC relationships is mentioned in literature based on the econometric analysis (Hofer, Barker & Eroglu, 2021).

The feedback of various sectors in the implementation of national information security directives and the challenges in achieving desired responsibilities, and the capability to watch over SC cyber security are seen in the literature. Further, the cooperation and support among the SC partners to enhance the efficacy of national information security implementation have also been highlighted (Wallis, Johnston & Khamis, 2021).

Researches on the relationship between supplier, integration of IT, logistic integration and organizational performance are found in the literature. Sutduean et al. (2019) have found that material and information flow significantly correlate with SC performance. Kakhki & Gargeya (2019) have classified the literature review on IOIS in SC management into six clusters. Studies concerning the relationship between IT standardization and SC performance and IT integration are also found in the literature. Saengchai & Jermsittiparsert (2019) have addressed the mediating role of IT infrastructure between standardization, integration and SC performance. The significance of port logistics in the era of Industry 4.0 is seen in literature. Sarkar & Shankar (2021 analyzed major barriers related to port logistics. They identified ways to achieve enhanced efficiency and reduce the cost of port logistics operations through data-driven decision-making.

Considering the vast advancements in digital technologies, the majority of the industries are looking forward to integrating IOIS with SC management, performance and gaining advantages in strategic decision making (Sorooshian & Panigrahi, 2020). Rawat, Rawat, Kumar and Sabitha (2021) effectively applied machine learning and data visualization techniques for decision-making in the insurance sector. The industry's potential can be boosted through technology adoption by aligning industry objectives with technology infrastructure, improving key features and performance. Information systems enable the transfer of knowledge and digital transformation, which influences the market through global pressure and meeting industry functions. IOIS adoption will bring structural changes within the organization. Hence, adopting information systems will enable the firms to transform data to information that benefits the decision-making process, resulting in better operative performance, enhancing profitability and gaining competitive advantage.

From the existing literature, it is found that the research on the influence of DMFs on the selection of IOIS is limited. The advancement in digital technologies results in continuous application and development of a decision-making model for SC management. MCDM based techniques and numerical simulation approaches are commonly used in developing decision support systems in SC. Application of decision support systems in the field of production (Gardas, Raut, Cheikhrouhou & Narkhede, 2019), construction (Guerlain, Renault, Ferrero & Faye, 2019), transactions (Brauner, Philipsen, Calero Valdez & Ziefle, 2019) and supplier relationships (Sahu, Sahu & Sahu, 2018) is seen in the literature. From the above discussion, it becomes clear that developing a decision-making model for selecting IOIS for SCD will be a novel contribution to the theory and practical applications.

2.3. Problem description and gaps in the literature

The research on big data and information systems theory building and adaptation methods lead to further research in information systems (Kar & Dwivedi, 2020). Literature reveals the requirement for further exploration of theoretical contribution in the studies on information systems. Decision-making based on data and relevance is increasing day by day, managed through proper IOIS. Kushwaha, Kar and Dwivedi (2021) have highlighted the requirement of further research in information systems, big data analytics and its applications. They also mention the need to develop competencies based on big data analytics, which can be achieved by analyzing the organization's stagewise capability-building process. The application of advanced technologies significantly impacts the implementation cost and adoption process, which requires further research (Kakhki & Gargeya, 2019). It denotes a gap in the literature due to enhanced complexity in the SC network and its management, which demands further investigation by researchers in IOIS adoption.

Further, research that offers practical guidance for IOIS adoption in firms is very few. Existing literature also reveals the need for further studies in IOIS due to advancements in digital technologies like e-commerce and open standard-based internet technologies. Hence, the literature review on the digital SC denotes a gap between theoretical studies and their practical applications. Further, researches on the implementation and decision-making process for SCD are very limited.

SC's of electrical and electronic equipment plays a vital role in the circular economy context, which is still not fully explored. Bressanelli, Pigosso, Saccani, & Perona (2021) highlight the requirement of further studies in the electronic SC to advance the circular economy by addressing the enabling role of digitalization, servitised business models, collaboration in electronic SCs, design strategies and assessment of social and economic benefits. A study on this aspect will contribute to the theoretical knowledge and its practical applications in developing a model for IOIS adoption in the SC. To our best of knowledge, no paper has attempted to study critical decision-making factors (DMF) to select IOIS for SCD. Hence, this research tries to address this gap in the literature in developing a suitable model for selecting suitable IOIS in an electronics supply chain. This study also tries to address the concerns of the scholars and decision-makers due to the uncertainties in selecting IOIS for SCD due to advanced technological developments.

3. Research methodology

This section deals with the research methodology used in the study. To shortlist the DMFs, a literature review was conducted to determine the factors that influence the selection of IOIS. Further, the shortlisted factors were evaluated and analyzed in consultation with the experts to identify the extent of the impact of DMFs on IOIS selection. The decision-making model considers the influence of the DMFs to rank and select the suitable IOIS solution alternative. The DMFs were evaluated based on the consultation with the experts.

Further, an integrated AHP-TOPSIS method is used to develop a decision-making model to select suitable IOIS alternative solutions. The model developed has considered and prioritized the DMFs influencing the IOIS solution. The experts were explained the method of assigning scores to the DMFs considering the relevance of each DMF. The DMFs were also classified under four major dimensions for effective management and decision-making. The study's findings were validated through case validation in an electronics SC and based on the feedback from experts and comparison with existing literature.

The electronics industry is one of the fastest-growing industries globally. The advancements in technology and innovations result in higher demand for consumer electronic goods with advanced features. The consumer electronics industry is facing severe challenges due to technological, environmental, and social developments. The significant difficulties include business risks (Migalska & Pawlus, 2020), social responsibility (Leclerc & Badami, 2020), regulatory norms (Oteng-Ababio, van der Velden & Taylor, 2020), competition (Jena, Sarmah & Sarin, 2019), shorter product life cycles (Huang et al., 2019) and changing customer demands (Li, Fang & Song, 2019).

To become competitive, the SCs of the electronic industry should be dynamic and equipped with advanced features. Considering the scope for the growth of the Indian electronics industry globally and government initiatives inviting global firms to commence production in India, the domestic electronic industry has to become more competitive to survive in the dynamic market. Further, considering the shorter product life cycle of electronic consumer goods due to technological advancements, customer requirements need to be met on time to gain market share. Hence, to strengthen the SCs of the domestic industry, SCs are to be

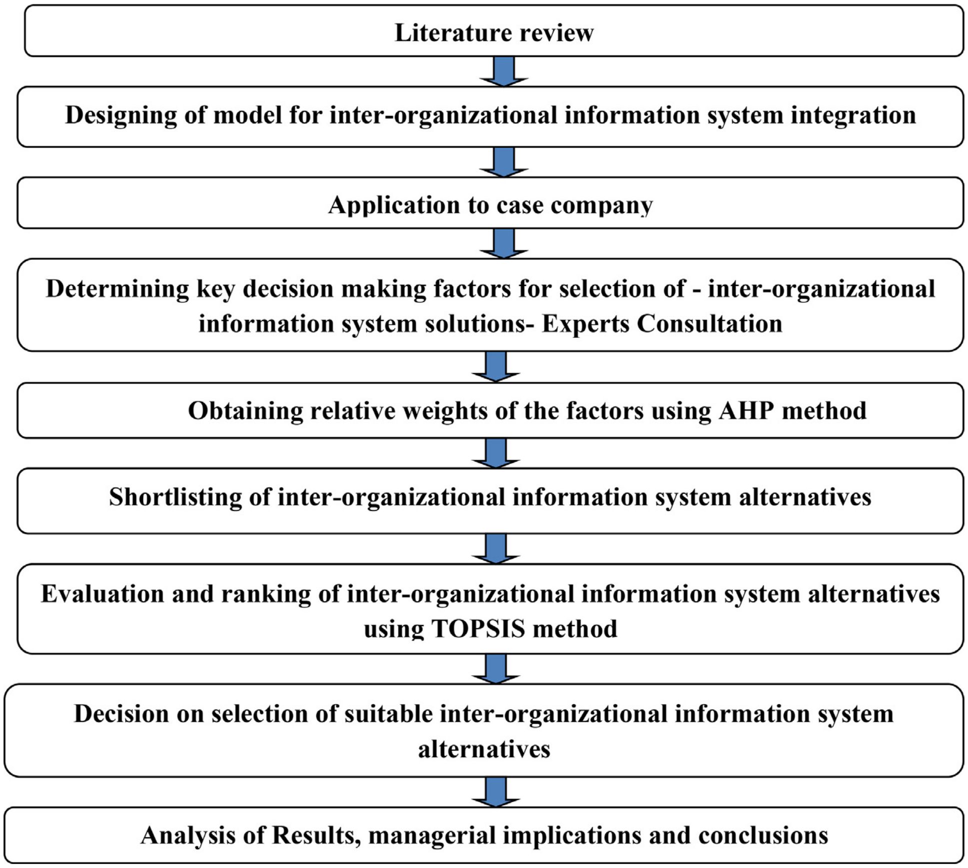

Fig. 3. Research methodology.

digitalized using the most appropriate IOIS solutions to gain maximum benefits. Further, the SC partners include multinational companies having effective operational capabilities and financial investments. Unlike in any other SCs with low technology applications, the electronic SC is more prone to changes in the market. Accordingly, the electronics industry was considered representative case research over other SCs and validated for selecting the most appropriate IOIS solution.

Kar (2015) developed a decision support system for supplier selection using a hybrid approach of AHP, Fuzzy set theory and neural networks. Further, constructivist theory and decision-making framework methodology are supported with a case study (Hakanen & Rajala, 2018). A case study is designed with an approach to technology development for forming scientific theory to build and verify the decision-making framework (Schallmo, Williams & Boardman, 2017). A diagrammatic representation of the research methodology is shown in Fig. 3. Due to complexities in prioritizing the strategies for digitalization, a decision framework considering new concepts and advanced methodologies is developed. An elaboration of the methodology used, its benefits and procedures followed are given in the next section.

3.1. AHP

Analytic Hierarchy Process (AHP) is an effective mathematical tool as it prioritizes the criteria and aids in effective decision making (Saaty, 1980). AHP is one of the methods used in decision support systems which is unique compared to other methods (Saaty, 1980). This method is most suited for assigning weights to criteria where multi-criteria decision-making situations are involved. It can also compare qualitative and quantitative indices, thus reducing cognitive errors by simplifying and comparing different attributes. These advantages of the AHP method make it most suited for applications in various domains like priority, ranking and optimization. AHP methodology has judiciously been used in several recent types of research for effective decision-making. For example, Mastrocinque, Ramírez, Honrubia-Escribano & Pham (2020) have used the AHP based model for a sustainable SC in the renewable energy sector. AyuNariswari, Bamford & Dehe (2019) have used AHP in the case of aircraft spare part inventory management. AHP method eradicates the issues of weighted scoring in assigning weights based on standard point estimation. The scaling done on the AHP method is more accurate than other methods. Kar (2014) used an integrated approach of Delphi, AHP and Cuckoo search for developing a decision support system in selecting suitable partner websites by identifying critical factors. In the AHP method, the weights of criteria and alternatives are calculated initially. Rani, Mishra, Rezaei, Liao and Mardani (2020) have used AHP to handle MCDM in the Pythagorean fuzzy problem.

While applying AHP, the matrix derived will be consistent only if the consistency ratio does not exceed 0.10. Accordingly, in this research, the consistency of results is checked, thus reducing the evaluator's bias. AHP consists of the following steps: (i) defining alternatives, (ii) defining problems and criteria, (iii) establishing priority among the criteria using pairwise comparison, (iv) consistency check, and (vi) finding out relative weights. A nine-point Saaty's scale is used in this research (Saaty, 1980). The experts consulted were asked to compare the DMFs on the nine-point scale based on the pairwise comparison. The nine-point scale allows the decision-makers in effective judgement among various options and its comparison.

3.2. TOPSIS

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) can evaluate alternatives through similarity with the ideal solution. In the TOPSIS method, the alternative close to the positive ideal solution and far from the negative ideal solution is considered the best alternative. The criteria that maximize the benefits and minimize the cost are considered the positive ideal solution, whereas the negative ideal solution maximizes cost and minimizes benefit criteria. Hence, a positive ideal solution comprises all the best values and worst values attainable against each criterion. Li, Fang & Song (2019) have used the extended TOPSIS method to develop a sustainable supplier selection model based on sustainable practices.

TOPSIS method is reliable and straightforward (Saaty & Tran, 2007). In the TOPSIS method, the chosen alternative would be close to the positive ideal solution and far from the negative ideal solution. Hence, while proceeding with the application of TOPSIS, the distances of positive ideal solution and negative ideal solution from each alternative are calculated. Subsequently, the closeness index of each alternative is calculated based on the distances for the positive and negative ideal solution and ranked accordingly. The TOPSIS method is initiated by identifying the alternative solution and calculating the normalized weighted matrix. Further, the value of positive and negative ideal solutions and the weighted distance of each alternative's positive and negative ideal solutions is calculated. Finally, the preference value is calculated, and the ranking of the alternatives is done (Chou, Yen, Dang & Sun, 2019).

3.3. Analytic hierarchy process integrated topsis method

In general, the problems involving decision-making calls for consideration of both qualitative and quantitative criteria. One of the decision-maker's challenges is the lack of precise knowledge about the system's factors. The proposed method helps in utilizing the advantages of the integrated approach against the particular MCDM methods. Thus, in this research, we have used hybrid MCDM methodologies integrating AHP-TOPSIS theory to handle uncertainties.

AHP method can consider quantitative and qualitative criteria, making it a preferred MCDM technique for decision-making in many operations management models. However, one of the limitations of AHP is the inconsistency of decision-makers in judging the criteria. This could be overcome by checking the consistency ratio to reduce the bias of decision-makers if any. TOPSIS method assists in decision making which can be used to measure alternative performance and decisions.

The ideal solution selected by applying the TOPSIS method will have the best value for all the criteria considered. Both tangible and intangible factors affecting the decision-making process can be viewed in this approach. To take advantage of the merits of AHP and TOPSIS, a combination of these methodologies is used to select the best IOIS alternative in this research. Kumar, Singh & Jain (2020) have used an integrated AHP-TOPSIS method to prioritize attributes in agile manufacturing in the Indian context. Bhattacharya, Raut, Gardas & Kamble (2020) have also used the above combination of methodologies to select efficient sustainable partners. Bathrinath, Bhalaji & Saravanasankar (2021) used a hybrid multi-criteria decision-making model using the AHP-TOPSIS method to identify and examine the most significant risks that create accidents in the textile industry. The selection of appropriate IOIS solutions for the digitalization of the SC can be made based on the ranking of the alternatives derived from the AHP-TOPSIS method. The following section deals with the decision model developed for the IOIS integration of SC.

4. Decision model for inter-organizational information systems integration of supply chain

Literature reveals that digital SC capabilities consist of planning, customer involvement, coordination, supplier involvement, and IT exploration. Further, the opportunity to achieve organizational benefit is possible with the help of technology enablers like digitizing, integrating, automating, intelligence and analytics. A road map for digitalization in healthcare SC was developed considering internal and external digitalization requirements. Beaulieu & Bentahar (2021) addressed the challenges in healthcare SC and strategies for maximizing the benefits through digitalization.

To proceed with digital transformation, firms should understand and analyze their internal and external capabilities. The digitization of the SC will enhance the performance of the firm by; (i) retaining customers, (ii)reducing operating costs, and (iii) increasing overall capability. Gaining SC capability will enhance competitive advantage through effective integration from suppliers through manufacturing processes. This research is novel as it addresses the steps to be followed for the digitalization of the SC. Fig. 4 shows a general schematic diagram of the model for digitalization of the SC for the IOIS integration process in any industry. The application of the integrated AHP-TOPIS method for decision-making in SCD should follow various steps, as illustrated in Fig. 4.

4.1. Steps for inter-organizational information systems integration

4.1.1. Step1: organizational vision in inter-organizational information systems integration

A firm's vision in digitization should be assessed before initiating steps in digitizing the SC. The firm's objectives and long-term vision also need to be evaluated. The nature of business activities should also be considered while determining the vision in the digitization of the SC.

4.1.2. Step 2: analysis of current situation and risks involved

The existing business and SC situation is critical and needs to be appropriately studied. Potential dangers of digitalization along with its feasibility need attention. Risk mitigation strategies could help offset potential risks.

4.1.3. Step3: finalization of implementation strategy

Implementation of digital technologies in the SC should be finalized by considering firms' internal and external capabilities. The firm's strategic, tactical, and operational objectives should be given due consideration at the time of implementation. These will help adequately plan and implement the required solutions in a sequential manner that suits the organization.

4.1.4. Step4: assessment of requirement of inter-organizational information systems

The extent of the necessity of technological and digital solutions to bridge the gap needs to be assessed. All SC partners need to be appropriately connected through practical digital technology tools, facilitating effective decision-making.

4.1.5. Step5: research and analysis on inter-organizational information systems effects

A thorough research and analysis of the impact of the implementation of digital technologies are needed to find out the changes and occurrence of disruptions, if any. Proper security and maintenance measures are to be adopted to set off the disruptions. A properly analyzed and implemented SC would be resilient and competitive.

4.1.6. Step 6: evaluation of inter-organizational information systems implementation

Implementing digital technology on both internal and external accounts must be assessed. The impact on the adoption of digital technology in the SC should be evaluated thoroughly. Necessary corrective measures or modifications can be planned if the effect on the business activity is adequately assessed.

4.1.7. Step7: finalization of factors for inter-organizational information systems decision making

Many criteria need to be considered while choosing or developing required solutions for digitization. Primary criteria that need consideration are digital technology enablers, project completion time, financial resources required, capabilities, ease of operations, post-sales product

Fig. 4. An integrated model for Inter-organizational information systems integration of supply chain.

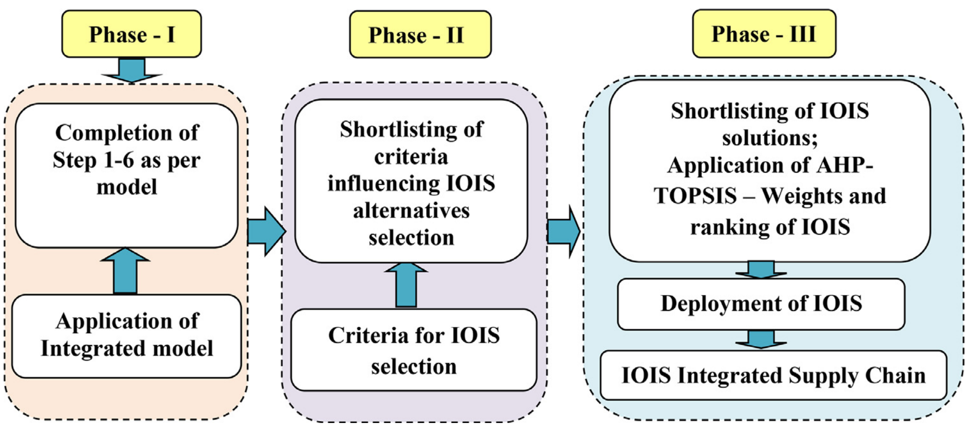

Fig. 5. Digitalization of supply chain- Integrated decision-making process.

support, brand name reputation, functional fit, and future scalability, control linkages among SC partners, information sharing across SC partners, business and data analytic and quality and risk control for decision making.

4.1.8. Step 8: assessment of inter-organizational information systems options and shortlisting

The possibilities of end-to-end software solutions should be considered by giving due weightage to primary criteria identified under step 7 above. The nature of the solutions available and their suitability to business, and adaptability to existing systems must be assessed.

4.1.9. Step 9: finalization of road map for implementation

After completing steps 1–8, based on results and decisions taken, a roadmap for implementation of the project could be finalized. The schedule of performance, along with the arrangements, is to be made for effective implementation.

4.1.10. Step10: Inter-organizational information systems Implementation and Upgradation

The final step in the digital transformation of the SC is its implementation and up-gradation. The solution should be deployed based on findings and, if possible, based on a pilot project mode for reviewing the results. Further, it should be appropriately upgraded or modified based on the requirement, as it is expected to run in a dynamic business environment.

Thus, an end-to-end reengineered digitized SC connecting all SC partners can be implemented by following the sequence of steps as detailed above. AHP-TOPSIS integrated method for IOIS integration of the SC is integrated into a three-phase activity as shown in Fig. 5 and explained below.

(i) *Phase I*- Application of integrated model for digitalization of SC: This phase considers the current assessment of the organizational conditions and capabilities. The process should be initiated by finalizing the organization's vision and assessing the prevailing situations in the market and associated risks. Based on the assessment, strategies for addressing the challenges and meeting the requirements for digitalization need to be finalized. Identifying gaps in technology and areas where digital applications can be used needs to be done, followed by research and analysis of overall impact and effects on the business activities.

(ii) *Phase II*- Shortlisting of key criteria influencing IOIS selection: Various criteria affecting the implementation of IOIS are shortlisted in this phase. The requirements of each SC partner and functional areas affecting the digitalization process are also given due attention.

(iii) *Phase III* - Application of integrated AHP-TOPSIS for ranking and selection of IOIS alternatives: After completing Phase I and II, the final phase deals with shortlisting IOIS alternatives and applying integrated AHP-TOPSIS methodologies. AHP method is used to determine the weights of DMF and TOPSIS method to rank shortlisted IOIS alternatives. After selecting the best IOIS alternative, effective strategies are to be adopted to deploy the same.

5. Application of the model to case electronics company

5.1. Case study

The model developed is applied in a case study and is discussed in this section. The SC of the electronics manufacturing industry is very complex. The electronics industry faces many challenges due to increased global competition, frequent changes in consumer requirements, and rapid advancement in technologies. Hence, all the developments and innovations in the firms dealing with autonomous vehicles, smart homes and connected cars can be associated with the consumer electronics industry due to the broader application of emerging technologies in the sectors. Digitalization has the potential to revolutionize the SC processes initiating from planning, sourcing, manufacturing, delivery, return, and after-sales service. IOIS adoption in the electronics industry assumes great significance as it enables electronic manufacturers to be more agile and innovative. The case study is performed on M/s.XYZ Company, which is one of the prominent consumer electronics companies in the electronics industry. The company is rapidly growing with a vast range of products and services and planning to expand the SC network further across the globe in line with the expansion strategy. Due to the recent advancements and developments in digital technology solutions, the company's top management believes that applying innovative technologies in their SC during expansion could bring more benefits against the existing system. Hence, from a long-term perspective, suitable provisions for effective management of the SC by digitizing the activities across the functional levels need to be considered by the company. Due to the challenges involved in selecting IOIS during the digitalization process, applying the proposed model will assist the managers in effective decision-making.

Accordingly, the model developed as explained in the previous section is evaluated in a case company. Experts in the company were consulted, and a discussion was held regarding the shortlisting of IOIS decision-making factors and IOIS solution alternatives. A series of interviews and meetings were held with industry experts representing various functional levels. The experts identified from the case company had an experience of more than ten years. Discussions were held with four experts, three from the case company and one from academia. The three industrial experts consulted were senior managers in Product Life Cycle Management, Information Technology and Operations Management. The fourth expert was a Professor in a reputed University researching Operations and SC Management. The academic expert was also associated with the automation of SC activities in various industrial projects. Hence, considering the vast work experience and functional areas of the experts consulted, the feedback and inputs are reliable and used in this research.

In the methodology adopted, twelve decision-making factors and four alternatives of IOIS solutions required for the XYZ Company in the electronics industry were shortlisted. As the company plans to expand the SC network globally, end-to-end solutions covering all aspects of the SC and the decision-making factors are considered. The criteria used for selecting IOIS consist of attributes on cost and benefit with various characteristics for assessment. An integrated model for IOIS adoption for the case electronics firm is shown in Fig. 6.

5.2. Decision-making factors considered for the case company

Based on the discussion and feedback from the experts in the company, the most relevant twelve DMFs for SCD through IOIS in the case company were shortlisted. The identification and classification of key DMFs help an organization in effective decision-making in selecting the most appropriate IOIS alternative solution for digitalization. The key DMFs identified are interrelated and not individual or standalone factors. Hence, this research has also classified the key DMFs identified, which will assist in effective decision-making.

Accordingly, the DMFs were classified under four primary dimensions: technological, operational, application, and innovative. The classification was based on the business model concept (Seppanen & Makinen, 2007), which resulted in the empirical classification of the DMFs. The business model concept deals with the classification of the resources under various groups. The major groups proposed in the business model concept include physical, informational, organizational, human, legal, relational and financial dimensions. The key groups considered in this research are based on the business model concept contains various sub-factors which are interlinked. Hence, considering the inter-linkage between the DMFs, they have been classified into four main groups: technological, operational, application, and innovative. A diagrammatic representation of the classification of DMFs is shown in Fig. 7. The key DMFs identified and their relevance to IOIS selection are shown in Table 2.

In this study, among the DMFs identified, the two tangible values considered are Financial Resources Required (FRR) mentioned in USD and Project Completion Time (PCT) mentioned in weeks. FRR is mentioned as the total funds required for the implementation of the IOIS solution for digitalization. Likewise, PCT is the time needed to complete the comprehensive implementation of the solution. For other DMFs, the expert evaluations are represented on a 1–10 scale. Various IOIS alternative solutions for the integration process by using IOIS are shortlisted and shown in Table 3.

A decision matrix is finalized based on evaluation decision-making factors, and four IOIS alternatives are shortlisted for consideration. The selection of alternatives depends on the influence of the decision-making factors shortlisted. AHP is used to find out the weights of twelve decision-making factors. In the AHP method, initially, the problems are defined, and goals are set, followed by arranging the problems into the hierarchy. Further, the priorities of each problem are identified, and weights are found out. The consistency ratios are found out to check the accuracy of the ratings. Accordingly, a pairwise comparison matrix for decision-making factors is done and is shown in Table 4. An example of DMFs mentioned in Table 4 is explained for better understanding. The capabilities (CAP) value in the fourth row and the first column is 0.5, which means Capabilities are 0.5 times as important as Digital Technology Enablers (DTE). The values mentioned in Table 4 diagonally are 1, showing the value for comparison with the same criteria. The pairwise comparison done is verified by finding out the consistency ratio. Based on the acceptable consistency ratio (under 0.10) obtained, weights of DMFs are found using the AHP method, shown in Table 4.

5.3. Results

In this study, four different IOIS alternative solutions were evaluated by the TOPSIS method to select the most suitable solution needed by the case electronics company. First, the weights of the criteria were determined based on the expert consultation. Then, the distances of the IOIS alternatives to the ideal solution were calculated. The weighted normalized decision matrix is computed, followed by positive and negative ideal solutions. Further, the relative closeness of the IOIS alternatives to the ideal solution is computed, and the alternatives are ranked accordingly. The results obtained for the case study using the TOPSIS method are given in Table 5. This table shows the values of separation distances of positive and negative ideal alternatives (d_i^+ and d_i^-) and relative closeness (C_i^+) to the positive ideal alternative for all alternatives. It is seen that Alternative 4 has come out as the best one, followed by Alternative 1. The ranking of Alternatives 2 and 3 remains in fourth and third position respectively.

The twelve major DMFs identified were categorized under four major dimensions. Based on the results of AHP, project completion time (0.193) is found out as the most important criteria, followed by digital technology enablers (0.178) and financial resources required (0.142), which falls as the top three decision making factors. The company concerns about the project completion time and digital technology enablers as the most prominent DMFs among all other criteria identified. Based on the case study conducted in an electronic firm, it can be concluded that Alternative 4 is found to be the most suitable IOIS alternative, which is from a well-known and established vendor.

The dynamic nature of the electronics industry and rapid product innovations results in a lower product life cycle, which demands the SC to remain competitive. SCD becomes important and assists in effective collaboration of SC, risk management, SC planning (Allaoui, Guo & Sarkis, 2019), sustainability, and reverse logistics (Agrawal & Singh, 2019).

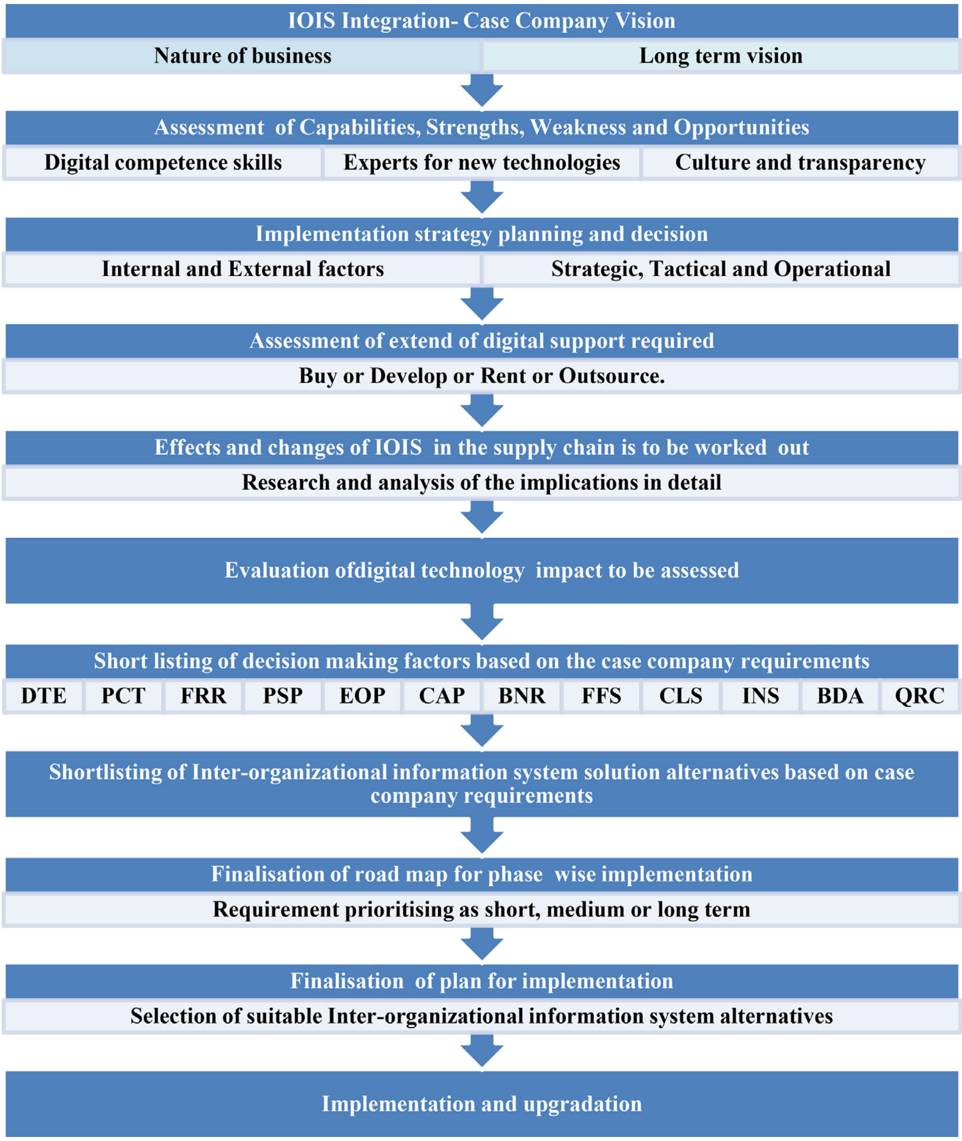

Fig. 6. An integrated model for Inter-organizational information system adoption in case electronics firm.
Legend: DTE: Digital Technology Enablers, PCT: Project Completion Time, FRR: Financial Resources Required, CAP: Capabilities, EOP: Ease of Operations, PSP: Post Sales Product Support, BNR: Brand Name Reputation, FFS: Functional fit and future scalability, CLS: Control linkages among SC partners, INS: Information sharing across SC partners, BDA: Business and data analytics, QRC: Quality and Risk control.

Fig. 7. Classification of decision making factors for Inter-organizational information systems adoption in case electronics firm.

Table 2-
Key DMFs and Relevance to IOIS Selection.

Sl No.	Abbreviation	DMFs	Refs.	Relevance to IOIS Selection
1	DTE	Digital technology enablers	Agrawal & Narain, 2021; Attaran, 2020; Schallmo et al., 2019	DTE creates a digitally enabled business model to bring SC partners on a common platform facilitating seamless communication.
2	PCT	Project completion time	Battula, Namburu & Kone, 2020; RezaHoseini et al., 2021; Shishodia, Verma & Jain, 2020	PCT should include a detailed plan of all processes and steps to be followed for completion.
3	FRR	Financial resources required	Jia, Zhang & Chen, 2020; Rodriguez-Espindola et al., 2020; Lee & Shen, 2020	Budgets are needed for SCD, which will result in adequate cost savings in the long run.
4	CAP	Capabilities	Andiyappillai & Prakash, 2020; Hastig & Sodhi, 2020; Taboada & Shee, 2021	Web-enabled capabilities can be utilized to the maximum possible extent while digitizing the SC.
5	EOP	Ease of operations	Salmi et al., 2020; Kulkarni & Halder, 2020; Martin, 2020.	Digital SC network compatible with the existing system and user-friendly makes the transformation process more straightforward.
6	PSP	Post sales product support	Jiang, He, Qin, Sun & Wang, 2020; Nergiz & Barutcu, 2020; Pasi, Mahajan & Rane, 2020	Requires support for providing training, upgrades of the software solution, call breakdown maintenance and support, fixing bugs.
7	BNR	Brand name reputation	Hassija et al., 2020; Wanganoo & Patil, 2020,	The company's reputation needs to be verified, based on references, as the project's success depends upon the vendor's reputation and brand.
8	FFS	Functional fit and future scalability	Abu-Elezz, Hassan, Nazeemudeen, Househ, & Abd-Alrazaq, 2020; Zhanget , Wei, Jiang, Peng & Zhao, 2021, Kopanaki, Karvela & Georgopoulos, 2018	Functional requirements and scalability to cope with the growing needs of the organizations assist in handling high business volume and data.
9	CLS	Control linkages among SC partners	Birasnav & Bienstock, 2019; Ding & Jie, 2021; Nazifa & Ramachandran, 2019	Control linkages can be established based on trust and commitment among SC partners, facilitating better performance and gaining a competitive advantage.
10	INS	Information sharing across SC partners	Jermsittiparsert & Rungsrisawat, 2019; Pham, Nguyen, Mcdonald & Tran-Kieu, 2019; Asamoah et al., 2021.	Aids in establishing proper linkage to effectively transmit information and develop long-term cooperation and coordination among SC partners.
11	BDA	Business and data analytics	Haulder, Kumar & Shiwakoti, 2019; Jha, Agi & Ngai, 2020; Ogbuke et al., 2020	Business and data capabilities help in effective forecasting and production activities that can scale businesses by gaining deeper insights from the data.
12	QRC	Quality and risk control	Hassija et al., 2020; Liang, Liu, Guo, & Liu, 2021; Mohammed & Duffuaa, 2020	Quality and risk control of information depends upon the trust among the SC partners.

Table 3
Scores of alternatives.

Criteria	Alternative −1	Alternative −2	Alternative −3	Alternative −4
DTE	7	6.5	5.5	8
PCT	14	19	16	12
FRR	17,000	19,500	18,000	13,250
CAP	6.5	4.5	5.5	7.5
EOP	7	7	6	8
PSP	6.5	4.5	3.5	6
BNR	6	6.5	5.5	7.5
FFS	8	5	5	8.5
CLS	6.5	5.5	7	7
INS	7	7	6.5	8
BDA	6	6.5	8	8.5
QRC	8	7	7.5	7

SCD also allows manufacturers to assess disruptions and plan for adjustments on a real-time basis. Electronics manufacturers should invest in business intelligence and event tracking capabilities due to dynamic changes in the business environment. Thus, it becomes evident that IOIS adoption in the electronics industry is significant and helps build cost-effective and responsive SCs (Naway & Rahmat, 2019).

Among the DMFs identified, Project Completion Time (0.193), Digital Technology Enablers (0.178), Financial Resources Required (0.142), Ease of Operation (0.116), and Capabilities (0.104) has come out as the top five DMFs for selection of IOIS. One of the significant findings is that the top three DMFs have come under operational dimensions. Thus, it can be inferred that DMFs under operational dimensions are given due significance while adopting IOIS. The project completion time should be given the highest weightage, as entire activities related to IOIS adoption should be completed within the minimum time. RezaHoseini, Noori & Ghannadpour (2021) have highlighted the significance of PCT while integrating SCs using IOIS, which should include a detailed plan of all processes and steps to be followed for completion. More time for integration will lead to disruption and a lack of effective coordination in SC activities.

Further to the consideration of time, digital technology enablers should be given due significance. DTE helps create a digitally enabled business model to bring SC partners on a common platform facilitating seamless communication (Schallmo et al., 2020). Advanced state-of-the-art digital technologies are to be considered for an effective SCD process. The latest developments in the technological arena need to be given adequate weightage for the selection and adoption of IOIS, resulting in the transformation of business models and better SC performance.

The financial investments required for adopting IOIS are another factor that is to be given due weightage. FRR refers to fund requirements for SCD, which will result in adequate cost savings in the long run (Rodriguez-Espindola, Chowdhury, Beltagui & Albores, 2020). The entire process needs to be done reasonably by developing a roadmap for integration through effective assessment of the existing SC. Further, the financial resources required are to be assessed considering the return on investment.

Ease of operation of the IOIS system facilitates effective implementation and usage of the system. SC partners should have the ease and accessibility of using advanced digital technologies. Introducing a digital SC network compatible with the existing system and user-friendly makes the transformation process more straightforward (Martin, 2020). An IOIS having greater ease of operation integrates and manages all activities in the SC effectively. It also allows SC partners to access data comprehensively anywhere and at any time. The capabilities of the IOIS system are to be adequately assessed before shortlisting IOIS alternatives. Hastig & Sodhi (2020) have highlighted the relevance of web-enabled capabilities and their utilization to the maximum possible extent in the process of SCD. IOIS integrates SC capabilities and technical capabilities. Global advancements and increasing uncertainties have led to increased SC challenges. Adopting an IOIS alternative with sound ca-

Table 4
The pairwise comparison matrix.

	DTE	PCT	FRR	CAP	EOP	PSP	BNR	FFS	CLS	INS	BDA	QRC	Weight
DTE	1	1	1	2	2	4	7	7	9	9	2	2	0.178
PCT	1	1	2	3	2	4	3	7	9	8	3	3	0.193
FRR	1	0.5	1	2	1	5	2	6	8	9	2	2	0.142
CAP	0.5	0.333	0.5	1	1	3	3	4	8	8	2	1	0.104
EOP	0.5	0.5	1	1	1	2	3	4	8	8	2	2	0.116
PSP	0.25	0.25	0.2	0.333	0.5	1	1	2	3	8	2	2	0.058
BNR	0.142	0.333	0.5	0.333	0.333	1	1	1	2	6	1	1	0.047
FFS	0.142	0.142	0.166	0.25	0.25	0.5	1	1	2	4	2	1	0.037
CLS	0.111	0.111	0.125	0.125	0.125	0.333	0.5	0.5	1	2	1	1	0.022
INS	0.111	0.125	0.111	0.125	0.125	0.125	0.166	0.25	0.5	1	1	1	0.015
BDA	0.5	0.333	0.5	0.5	0.5	0.5	1	0.5	1	1	1	5	0.047
QRC	0.5	0.333	0.5	1	0.5	0.5	1	1	1	1	0.2	1	0.040

Table 5
Results of TOPSIS method.

Alternative	d^-	d^+	C^+	Rank
Alternative 1	0.0466	0.02840	0.62146	2
Alternative 2	0.0169	0.06289	0.21195	4
Alternative 3	0.0225	0.05537	0.2893	3
Alternative 4	0.0705	0.00388	0.94787	1

pabilities makes the SC robust and dynamic and enhances its competitive advantage.

Further, post-sales product support (0.058), brand name reputation (0.047), functional fit and future scalability (0.037) and control linkages among SC partners (0.022) are the DMFs that are to be given priority. The process of digitalization and maintenance requires support from service providers or development teams for providing training, upgrades of the software solution, call breakdown maintenance and support, fixing bugs, if any (Nergiz & Barutcu, 2020). Further, the company's reputation that develops the software is another criterion to be considered and verified, based on the references, as the project's success depends upon the vendor's reputation and brand (Wanganoo & Patil, 2020). The functional requirements and further scalability of the IOIS to cope with the growing needs of the organizations should also be considered, as it includes the capability of the IOIS solution to grow and handle high business volume and data (Abu-Elezz, Hassan, Nazeemudeen, Househ, & Abd-Alrazaq, 2020).

Control linkages among SC partners can be established based on trust and commitment among SC, facilitating better performance in the short term and long term goals that could result in competitive advantage and better business activities (Ding & Jie, 2021). The information sharing across SC partners helps establish a proper linkage among the SC partners for the effective transmission of information and establishing long-term cooperation and coordination among the partners in the SC (Asamoah et al., 2021).

Analysis of business and data based on the access to integrated information helps make effective decisions on SC activities through effective forecasting and planning production activities, which helps in scaling business by gaining deeper insights from the data (Ogbuke, Yusuf, Dharma & Mercangoz, 2020). Finally, quality and risk control is another major factor that is to be considered while selecting IOIS, as the quality of information depends upon the trust among the SC partners (Hassija, Chamola, Gupta, Jain & Guizani, 2020).

6. Discussions

The technological advancement and its application in SC have made adopting IOIS a prominent topic for research. To survive in the competitive business world, it has become necessary to proceed with the digitalization of SC. Literature mentions the importance of companies' competitive advantage due to digitalization. Hence, companies that decide on the digital transformation vision will perform better. Further, digitalization of the SC chain would enhance capability resulting in high operational performance.

The integrated model developed for digitalization of the SC using IOIS, as illustrated in Fig. 5, describes dimensions, strategies, and overall contents of the integration process that could enhance the scope for SCD. Digitalization requires a robust change that involves the commitment from top management, innovative thinking, and support from the SC partners like suppliers, customers, and employees. The successful implementation can reap benefits in higher profits, better performance, flexibility, and higher SC efficiency. Further, the proposed model can help SC managers and practitioners integrate the SC and standardize the processes. The study's theoretical & managerial implications, limitations and future scope are mentioned in the following sub-section.

6.1. *Theoretical implications*

The findings from this research provide managerial and theoretical implications for selecting suitable IOIS solutions considering the influence of key DMFs. This research contributes to the theory of SCD by assisting in understanding the key DMFs influencing the selection of appropriate IOIS solutions. It also provides better insights into the significant DMFs and their inter-relationships that affect IOIS alternatives. The IOIS integrated SC research framework developed assists in enhancing the literature base and knowledge on SCD by providing better insights for researchers and academicians. The model developed will also assist the managers and policymakers devise suitable strategies for selecting appropriate IOIS selection leading to SCD. The decision model developed can be used by scholars and practicing managers for conducting a more comprehensive level of examination of the key DMFs and selection of IOIS in another industry or firm. The research outcome can also be used in identifying and categorizing the key DMFs for effective digitalization. The relationship among the key DMFs can be understood effectively using the results of this research. Further, the requirement of an innovative SC network and its design can be materialized based on applying the decision-making model developed in this research.

6.2. *Practical and managerial implications*

The model developed in this research can be used by the managers and decision-makers dealing with uncertainties of selecting appropriate IOIS solutions. As a result, managers can make effective decisions based on the model for improving the efficiency of organizations. Further, the model developed can be applied in any industry by identifying the applicable DMFs and shortlisting alternatives. It also assists the companies in establishing a systematic approach for selecting IOIS considering a set of key DMFs. The advancement in digital technologies and this research concentrating on the consumer electronics industry allow firms to create better opportunities for revenue generation through innovation using IOIS. Due to similarities in the SC functions followed by various companies, its practices can be considered a global practice in SCs, even though country-specific bias can influence it.

6.3. Limitations and future scope of research

This study has a few limitations as well. One of the limitations of the AHP method is the subjective nature, wherein the weights are assigned by decision-makers based upon the individual opinion. Pairwise comparisons among variables using AHP is a laborious and time-consuming task. The complexity of calculations would increase with the number of criteria. Even though the experts consulted for pairwise comparisons were renowned people in their field, the bias of experts towards the criteria might have influenced the final results. We have tried to address it by use of consistency index (Saaty,1980). The proposed model has been applied to a company in the electronics Industry. Hence, the model needs to be studied and examined further by the researchers working in other sectors. Future research could also attempt to test the findings of this study using different multi-criteria decision-making methodologies. The decision model developed in this paper is generic and can quickly be adopted by other companies with marginal changes by adding more criteria and sub-criteria specific to the industry concerned.

In this research, we have identified and considered twelve DMFs only, which is one of the limitations of this research. Hence, future research can be done by considering more DMFs, and the findings can be verified. Further, the key DMFs were shortlisted based on literature review and discussion with experts from the electronics industry and academia. Validation of the model developed was done in an electronics SC. Hence, the model needs to be validated in the SCs in other industries considering the DMFs specific to the industry. Further, a different multi-criteria decision-making method could gain better insights regarding the adoption of IOIS in SCs.

7. Conclusion

This paper develops a decision model for IOIS adoption by considering the key DMFs that affect the SCD process and shortlisting IOIS solution alternatives. Further, the model developed is validated through a case study in an electronics SC. AHP integrated TOPSIS method is used in the model to analyze the DMFs and ranking of IOIS alternatives. The main focus of the study is on selecting suitable IOIS solutions for effective supply chain digitization and its management. The existing SC models available in the literature are insufficient to decide upon the digitalization process using IOIS.

Further, literature on developing a model for SC integration through digitization is rarely found. In this study, the model's capability to integrate activities in the SC using digital technologies is addressed and tested with a case study. This study tries to address the knowledge gap in the procedure by developing a suitable model for digitalizing the SC by adopting IOIS. Accordingly, the key decision-making factors for selecting IOIS solutions were identified from the literature and shortlisted in consultation with the experts. Further, a model for SCD by adopting IOIS was developed and validated through case evaluation using a hybrid AHP-TOPSIS method. The model was developed by considering the nature of the business activities and SC requirements. The proposed model helps to identify the main DMFs for the prioritization and selection of suitable IOIS alternatives. Overall, the proposed method is effective and less time-consuming.

The model presented in this paper would enable the researchers, practitioners, and academicians to understand better the SC processes in case of factors affecting selecting suitable IOIS alternatives. The proposed method can also identify and select suitable IOIS required by an organization to digitalize its business activities. Functional areas that are to be digitized in the organization need to be found, and the model can be applied for effective digitalization. This research also helps provide insights into the process of shortlisting criteria and selecting suitable IOIS alternatives. The proposed model shows that integration of SC results in better visibility and enhances SC capabilities. The practitioners can also use the model on a much broader basis in various industries for effective SC integration using IOIS. Hence, as a preliminary stage, the integrated MCDM approach developed in selecting appropriate IOIS provides better insights in achieving the desired results.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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