

Investigation of capillary tools to reinforce the decision-making capabilities for transforming SCM into smart supply chain management (SSCM)

Sanju Kumar Nishad, Arvind Sahu, Atul Kumar Sahu and
Somnath Singroul

*Department of Industrial and Production Engineering,
School of Studies of Engineering and Technology, Guru Ghasidas Vishwavidyalaya,
Bilaspur, India*

Abstract

Purpose – In the present study, a group of capillary tools are presented with the purpose to reinforce the decision-making (DM) capabilities of supply chain management (SCM) and to transform SCM into smart supply chain management (SSCM). Here, a bunch of DM tools are presented that can assist in providing thinking capabilities to multiple segments of the activities of supply chains (SCs).

Design/methodology/approach – In this study, the literature review is considered as a research methodology, where the main thrust of the methodology is to determine the capillary tools for SSCM design based foundation for reinforcing SCM activities. The study mapped the existing literature knowledge related with DM tools to present a surface picture of capillary tools that can provide self-thinking capabilities and DM power to SCM. In this study, a thorough investigation is presented to interpret the overall pictorial representation of SCM assets that can be managed by DM tools.

Findings – The findings of the study have admired the utility of various support tools, i.e. agent-based system (ABS), the genetic algorithm (GA), an expert system (ES), artificial neural network (ANN) system, big data (BD) techniques, deep learning and natural language processing (NLP) prominent to be implicated for handling and maintaining the diverse SCM activities. The study has described support tools that can be implemented under the domain of SCM to import self-thinking capabilities, induce decision-making power for SSCM, create alerts, inform companies about state of mismanagement, forecast true need of concerns and to lead in evading SC troubles.

Originality/value – The study originally presented SCM-related activities and mapped the appropriateness of capillary tool to be used to create an understand-ability about the importance of capillary tools for managerial solutions. The study originally provided a widespread impression of diverse DM capillary tools that can be used to handle widespread stream of SCM activities to make it more sustainable. In this study, discussions pertaining to various support tools are presented for estimating their potential and implementation in handling the accurate SCM activity, and the arguments are presented for building SSCM designs based on the need of capillary tool to handle SCM activity.

Keywords Resilient, Smart supply chain management (SSCM), Decision-making,
Supply chain management (SCM)

Paper type Research paper

1. Introduction

Today, each and every business atmosphere is surrounded by supply chains (SCs), where their related success and survival depends on the management of that SC (Ahmed *et al.*,



2022; Mishra *et al.*, 2023). The conceptual understanding and management of SC relies on estimating various facts, demands, issues, persons, assets, network and activities that must be considered for designing, planning and operating it fruitfully. Accordingly, it is indeed a requirement of the concerned decision-makers to load critical capacities to the SC to receive prominent benefits from SC decisions and SC performance (Sharma *et al.*, 2022; Shah *et al.*, 2023). Supply chain management (SCM) and its transformation towards smart SCM depends on how deliberately a decision-maker synchronizes, maintains and manages the constant flow of information, activities, stuffs, services, products and funds under the stages of planning to the customer end and towards final destination. Thus, there is a need to rethink the various prospects, process, tools and network-related activities based on the availability of decision-making tools for reinforcing the capabilities of the SC (Wamba *et al.*, 2021; Richter *et al.*, 2022). Nowadays, there is a need to amalgamate various capillary tools over traditional SC system, which can assist in loading the true capabilities for the survival, management and success of the system. Accordingly, this present study is conducted by the authors towards displaying the role of numerous tools that can implement on the SC to reinforce the capabilities of SC and to transform traditional SCM into smart SCM. The present study is conducted by the authors to report the below mentioned research objectives (ROs):

RO1. Why capillary tools are required in SCM and what are the widespread stream of SCM activities that require capillary tools?

RO2. What are the various capillary tools that can implement on the SC to reinforce the capabilities of the SC and can transform traditional SCM into smart SCM?

In responding to the above ROs, the present study is conducted to objectively demonstrate multiple SC activities and to report allied tools for implementation that can fruitfully assist in evading resilient and state of mismanagement of scenario and situations under SCM activities. The study is structured in six sections, where [section 2](#) represents the proportions of literature review under the dimensions of customer value and future SCM under capillary tools, while [section 3](#) outlines the motivations and gaps. Methodology is described in [section 4](#). Implications and Discussions are represented in [section 5](#). Conclusion is represented in section 6.

1.1 Literature review

A wide extent of literature studies from SCM and intelligent tools are exploited by the authors to understate the capillary tools and to embrace crucial studies under integrated zones. The study objectively investigated the conceptual dimensions of SCM, where it is identified that the frameworks based on intelligent tools in SC are needed to lead the mediating role of collaboration and information to positively impact SC performance (Nishad *et al.*, 2024; Martinčević *et al.*, 2021). Today, the application of crafting intelligence based on the application of various tools is needed to endeavor significant influence on SC (Neugebauer *et al.*, 2021; Diaz *et al.*, 2021). The integration of novel tools and technologies, including their definitions, capabilities and applications, is needed for providing a significant clutch in the development of projects related with optimization (Min *et al.*, 2019; Pournader *et al.*, 2021). It is found that the recent advancements in robotics can be possible by embracing artificial intelligence (AI)-based capillary tools and applications such as deep learning (DL), reinforcement learning, machine learning and advancement in hardware. The automation of tasks, which are traditionally performed by humans in SC are now needed to be automated, where capillary tools can assist in maintaining the retraining programs. Capillary tools under SC are needed to embrace key impact in the form of productivity, intelligence and drafting efficiency in various industries. These tools can reward automation of repetitive tasks and can

optimize processes, by way of which businesses can lower costs and improve output (Klumpp, 2018; Modgil *et al.*, 2022).

Capillary tools can be used to craft AI capacities towards enabling the emergence of new business models, which will handle on-demand services, personalized customer experiences and data-driven decision-making (Benzidia *et al.*, 2021; Li *et al.*, 2023). Consequently, one can assume that capillary tools in SC are needed for fundamentally shifting the business and attaining economic landscape under the dimensions of individuals, industries and societies as a whole. Traditional SC in the present state should adapt new technologies, and a deemed integration of these technologies is needed amongst aforesaid in the shape of “augmented supply chain” or maintain “smart supply chain” with the prospects to improve efficiency, sustainability and customer service (Rodríguez-Espíndola *et al.*, 2020; Bag *et al.*, 2021). These technologies should be applied throughout the SC starting from material handling to production to distribution to customer service to warranty. These advancements are needed to improve efficiency based on the integration and analysis of seamless data exchange and collaboration across different parts of the SC for success (Canhoto and Clear, 2020; Kottala and Sahu, 2023). The authors have accordingly presented cluster of capillary tools to assist practitioners in mounting decision-making capabilities in different segments of SCM.

The implication of capillary tools can portray the fourth era of industrial revolution, where the implications of bunch of these tools are needed to boost analytical efficiency and intelligence (Baryannis *et al.*, 2018; Haenlein and Kaplan, 2019). Their implication can build analytical strengths to the SC systems, provide potential of transforming business, lead in deriving solutions based on data impact, analytics and more importantly suggest the likelihood of occurrence of disruptive event in a system (Hartley and Sawaya, 2019; Modgil *et al.*, 2022). It is realized by the authors that the process of apprehending capillary tools on the system characteristics starts with the basic understanding of what they are, how they will impact the enterprise, what the current capabilities are and what should be a viable action strategy to evade resilient scenario. Accordingly, a bunch of capillary tools and their importance in a designated zone for handling SC activities are presented to reinforce SC capabilities and for the purpose of transforming traditional SCM into smart supply chain management (SSCM).

1.2 Customer value and SC cost

The management of customer value and SC cost depend on SC drivers, which requires capillary tools for decision-making. Decision-making (DM) is required under wide drivers, where the drivers related with facilities are responsible for the management of extreme costs, savings and revenues (Calatayud *et al.*, 2019; Wamba and Queiroz, 2020). Capillary tools are needed to endure decisions regarding the location, capacity and flexibility of facilities to have a significant impact on the SC performance. Additionally, the same are required to handle drivers related with transportation that can take the form of many combinations of modes and routes, each have its own performance characteristics and delivers significant importance in managing costs, savings and revenues (Sahu *et al.*, 2023; Jauhar *et al.*, 2023). Furthermore, the same are required to handle drivers related with changing inventory policies that can dramatically alter the SC efficiencies, costs and responsiveness. Accordingly, one can say that capillary tools are indeed the need for reinforcing above said drivers.

Next, the drivers related with the development of right information and its right understandability can help in securing cost, satisfaction and efficiencies (Isabel, 2015; Foo *et al.*, 2018). The same needs capillary tools to analyze data related with facilities, inventory, transportation costs, prices and customers throughout the SC. Information is potentially the biggest driver of performance in the SC because it directly affects each of the other drivers. Importantly, the evaluation of drivers related with sourcing a particular SC

activity, i.e. production, storage, transportation or the management of information to responsible man, machines and places, is significant to evaluate (Dirican, 2015; Plastino and Purdy, 2018). It is found that warehousing and transportations endures the vital components of the SC, and it is found prominent to seek chief attributes in logistics and smart warehousing boundaries to enhance the organizational power and success (Min, 2010; Sahu *et al.*, 2024), where capillary tools can provide certain benefits in intelligent demand forecasting, inventory optimization, equipment optimization and predictive maintenance. Additionally, automation, process optimization, real-time visibility, asset tracking, enhanced order fulfillment, continuous improvement and enhanced safety can be attained by deploying capillary tools. Furthermore, automation and optimization of processes related with route planning, demand forecasting, inventory management, delivery schedules and tracking of resources can be done with the usage of capillary tools in SC. The same can swiftly evaluate huge amounts of information from a mixture of sources and identify patterns and trends to be used for predictive analytics and to present critical facts, disclosures and managerial solutions. The application of capillary tools in the warehousing operations can improve the abilities of the warehousing performance under the streams of logistics, management and co-ordination.

It is found that capillary tools can be frequently associated and implemented to delve anticipated autonomous and predictive capabilities to the drivers of the SC and to build the structure of future SCs (Klumpp, 2018; Modgil *et al.*, 2022). But it is found that such tools and capabilities have key challenges, opportunities and the same are surrounded by many barriers and challenges and accordingly, it is always needed to evaluate the directory of challenges and barriers towards building a new SC model having autonomous and predictive capabilities, i.e. the self-thinking SC (Rodríguez-Espíndola *et al.*, 2020; Bag *et al.*, 2021).

1.3 The future of SCM under capillary tools

The future of SC is all about marinating responsiveness and providing a delightful experience to the customer with the satisfaction of each and every one exiting in the network of SC (Neugebauer *et al.*, 2021; Diaz *et al.*, 2021). Traditionally, the SC network is managed in the form of a linear model and the same assumes that the evaluation of static characteristics is sufficient for fruitful management of SC. Today, the SC needs redesign based on the implementation of intelligent nodes and applications. Every node of the network must be attuned and designed as per the flexible needs of the consumer towards being capable of addressing factors such as sourcing, trade policies, modes of shipment and more. It is argued that creation of an SC demands assurance that the information and statistics contained by them will be constructive and can realize in attaining the objectives of the SC (Baryannis *et al.*, 2018; Haenlein and Kaplan, 2019). Accordingly, in present study, a bunch of capillary tools are presented that can assist in DM power to multiple segments of the activities of SC.

It is affirmed that advanced technologies can be used to improve transparency and visibility throughout SC network, as well as to further enable connectivity and SCM utilization (Hartley and Sawaya, 2019; Modgil *et al.*, 2022). The entire SCM planning function will become more intelligent by the implication of capillary tools as a technological means to take consumer demands into account. In the past, SC planning has been a periodic business exercise, and future SCM systems need alignment between planning and execution, which is not a current state for most enterprises. The need for speed and accuracy in SCM is needed to increase, and accordingly, it is required to make sure that the SC is loaded with acceptable tools to embrace intelligent SCM system and to make it ready for the future (Dirican, 2015; Plastino and Purdy, 2018). Capillary tools can be prominent in this regard and can be easily implicated in the boundaries of SCM to add value to the SC planning, including production, inventory management and product distribution.

It is found that big data (BD) analytics-powered intelligence has recently grown in modern years. The literature indicates that BD based analytics provides elevated powered and can load SC with the ability to enhance its performance (Min, 2010; Sahu *et al.*, 2024), but a limited research has been so far conducted by the researchers towards presenting the rational explanation of capillary tools that can help in manufacturing activities by adopting BD analytics. Many researchers addressed this gap by employing subjective theories, rough sets theories and institutional theory. Many researchers have used resource-based view theory to make understanding of critical barriers that can support to drive technological enablement and improve sustainable SC practices towards the development of circular economy. Today, capillary tools are required to help business organizations to get almost 100% accurate projection and to lead in forecasting the customer demands, supplies status, optimizing R&D, decreased manufacturing cost and delivery of higher quality, which thereby provides customers with a superior experience and right promotion. The same are considered by the authors in this study and accordingly, the study analyzed various theories related to capillary tools that can help in SSCM design.

1.4 Capillary tools in DM

Capillary tools are defined as the tools that can be elementarily applied to any system for boosting its performance. It can be in the form of physical or intangible assets, techniques, equipments and so on. Capillary tools can induce the ability of machines to perform tasks that are typically associated with human intelligence, such as learning and problem-solving. The same can be used to develop a multi-dimensional intangible framework to add value in the planning of human-artificial collaboration and handling dynamic systems in SCM. Nowadays, in the era of competency and highly uncertain external environment, it is deemed necessary to maintain competitive advantages in SC for long run. Thus, there is an urgent need to acquire a more widespread and sustainable competitive advantage for reshaping the industry structure and competitive dynamics (Ning and Yao, 2023; Namagembe and Mbago, 2023). It is found that aligned practices and technology having compatibility with working elements are needed to be investigated for achieving and retaining a significant relationship amongst dependents to improve SC presentations (Nakabuye *et al.*, 2023; Koot *et al.*, 2021). Accordingly, capillary tools are needed in SC towards importing self-thinking deliveries and capacities.

Today, it is needed to extend the branches of capillary (elementary) tools to provide dynamic approach for parameter adjustments (Isabel, 2015; Foo *et al.*, 2018). Capillary tools can be used to draft intelligent and to prepare a less complex decision support framework and a novel approach for solving decision-making problems. Thus, one can understand that the system, where already decision support framework are integrated, needs to be re-engineered, re-made and re-designed, considering the components and complements of capillary tools as a power source towards improved DM (Benzidia *et al.*, 2021; Li *et al.*, 2023). The same can be used to boost the virtual representation of a system. Here, in study, the authors have accordingly presented a bunch of capillary tools and highlighted the importance of integrating capillary tools with the intension to reinforce the capabilities of SC and to renovate the traditional SCM into SSCM. The pictorial representation of usage of capillary tools in different stages of SC can be understood from Figure 1.

Today, for having the larger implementation and acceptance of developed technology, digitalization is an indeed need for industries, where digitalizing their assets and operations is a challenge. Accordingly, it is required to identify decision-making tools for providing analytical capabilities to squeeze right decision and maturity (Baycik and Gowda, 2024; Moraes *et al.*, 2025), which requires capillary tools for association with the system dynamics to build much faster and more effective system architectures to maintain SC of the future. It is hereby understood that the capable tools and unavoidable barriers

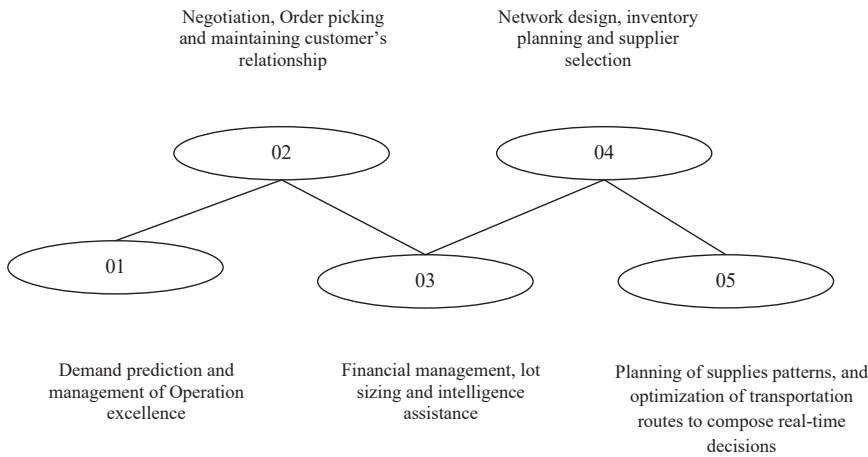


Figure 1. Usage of capillary tools in different stages of SCM. Source: Authors' compilation

confronting the journey of optimization with digitalization should be exploited in studies for true transformation, which are for imparting decision-making pillars to the developers and practitioners (Sundarakani *et al.*, 2024; Ahmadi *et al.*, 2025). The present study is quite a landmark under that zone, which is accordingly conducted by the authors to provide recommendations to the organization related to capillary tools to implement and to embrace larger benefits from digital transformation. It is worthwhile to summarize a zone of multiple emerging tools and technologies in a single study for enduring transformational capabilities to operations and SC by the practitioners (Massari *et al.*, 2025; Li *et al.*, 2025). To remain competitive in unstable business environments and to estimate the growing environmental challenges, modern SCs should undertake transformations based on circularity, agility and resilience (Ahmadi *et al.*, 2025; Moraes *et al.*, 2025), where capillary tools can handle optimizations under a widespread impression of many diverse stream of SCM activities to make it more sustainable. The capillary tools are hereby presented in this study as a segmental asset to boost profits and transformations in SCM based on pre-estimating and triggering decision aspects.

2. Motivations and research gaps

Today, analytics capabilities are thoroughly needed to implement in business to help organizers in mounting and realizing the required characteristics, which consumers or users want in products. Additionally, the same are needed to optimize logistics routing troubles, evaluate possibilities, determine risk predictors and to contribute towards behavior analysis, route integration and optimization of logistics resources due to uncertainty (Ren *et al.*, 2024). The same are required for determining holistic performance, implications of partners, supports for acceptability and savings (Tetteh *et al.*, 2024). It is determined that visibilities should be imported in SC dynamics based on certain nomenclatures, driving mechanism, network maintenance and optimization tools, where supply visibility and demand visibility can reinforce system capabilities, which consequently lead to product innovation, supply management and facilitation in exploiting specific requirements from product performance management, cooperation, integration and development (Hu *et al.*, 2024). The same can help in determining the divergent patterns of both demand and supply along with customer's intensions in different domains to evade disruptions and to retain restoration stages in manufacturing, ordering, unbalancing, threatening, partnering and building strong

relationships for preserving revenues (Jiang *et al.*, 2023). Thus, tools that can help in the visibility of SC are needed to identify leaders in imparting self-thinking capabilities for pacing growth and securities (Moleme *et al.*, 2024). Accordingly, the present study is conducted to identify and map a specific SC activity under a capillary tool. The identification, mapping and demonstration of capable tools and allied SCM activities are hereby presented for dealing with the journey of optimization, for precise transformation of SCM and for imparting decision-making pillars to the developers and practitioners for advancing SCM knowledge and practical dimensions. The importance of the study lies in presenting diverse tools to the business organizations for optimizing different dimensions of SCM for patching smart performance. Today, smartness in SC is requisite based on green performance, agility, leanness and so on from external participants as well as internal participants (Lerman *et al.*, 2022; Nishad *et al.*, 2024). The same demands capillary tools to help in providing SC towards self-thinking capabilities, which can be decided from present study. The integration, which can help SC to either observe or predict disturbances, is prominent. Furthermore; the moves that can assist SC from physical SC monitoring to autonomous decision-making are needed to seek and develop for inducing sustainability. Consequently, the dimensional capillary tools are sought based on literature studies and this study, which can enhance flexibility and predictions based on analysis of data pertaining to contextual behaviors, trends, patterns, awareness and communication.

After studying a class of research studies, it is identified that a low degree of research studies has been done that can assist in building smart SCM design, which is considered as a historic research gap for the study. Additionally, it is found that a little attention has been found in literature studies, which have presented theoretical portfolio of SCM and intelligent tools in a single window. The same is considered as a secondary research gap for the study. Today, there is an evident usage of available tools, which can show great promise in improving human decision-making processes and productivity in various business endeavors based on recognition of business patterns, learn business phenomena, seek information and analyze data intelligently (Calatayud *et al.*, 2019; Wamba and Queiroz, 2020). Despite widespread availability of decision-aid tool, there has seen a limited application of these tools in SCM. Supply chain processes can be augmented and changed with huge injection of new technologies, decision-making tools, novel benchmarks and so on to become more sustainable (Sharma *et al.*, 2022; Shah *et al.*, 2023). Accordingly, the study has embraced its dimensions under the primary objective to analyze various theories related to the application of elementary tools that can be used in the form of capillary in SCM for developing SSCM design. The bunch of intelligence tools are presented in study that can assist in DM power to multiple activities of SC and can truly assist in implementing the full usage and motives of SCM capabilities.

3. Methodological framework

In this study, the literature review is considered as a research methodology, where the main thrust of the methodology is to determine the support tools and techniques, which may have an influence and capacity to transform traditional SCM to SSCM. After interpreting the literature review, various support tools, i.e. agent-based system (ABS), the genetic algorithm (GA), an expert system (ES), artificial neural network (ANN) system, BD techniques, DL and natural language processing (NLP), are found prominent to be implicated for handling and maintaining the diverse SCM activity. The corresponding sources, which admire the authors to consider these techniques for discussion as capillary support tools, are shown in Table 1. The study has prompted the discussion about aforesaid tools to highlight their utility and implication under the extent zone of specific SCM with clarity. The tools, i.e. ABS, GA, ES, ANN, BD, DL and NLP, are found significant for declaring their existence under the boundaries of SCM and to make it a smart SCM. The ABS is admired towards modeling a computational system that is composed of multiple

Table 1. Capillary tools and allied sources towards strengthening SCM capabilities

S. N	Capillary tools/technique	Source
1	Agent based system (ABS)	Helo and Rouzafzoon (2023), Helo <i>et al.</i> (2018), Holzfeind <i>et al.</i> (2021), Lohmer <i>et al.</i> (2020), Rouzafzoon and Helo (2016)
2	The genetic algorithm (GA)	Babaeinesami <i>et al.</i> (2022), Min (2015), Sayed Saif-Eddine <i>et al.</i> (2019), Kannan <i>et al.</i> (2010), Katoch <i>et al.</i> (2021)
3	An expert system (ES)	Errasti <i>et al.</i> (2010), Jin and Rong (2011), Ernest <i>et al.</i> (2010), Jędrzejczyński and Robak (2010)
4	Artificial neural network (ANN)	Chiu and Lin (2004), Meidute-Kavaliauskiene <i>et al.</i> (2022), Soori <i>et al.</i> (2023), Abdallah <i>et al.</i> (2022), Biswas <i>et al.</i> (2019)
5	Big data techniques (BD)	Zamani <i>et al.</i> (2022), Koot <i>et al.</i> (2021), Addo-Tenkorang and Helo (2016), Dubey <i>et al.</i> (2019), Gunasekaran <i>et al.</i> (2017), Hopkins and Hawking (2018)
6	Deep learning (DL)	Khedr and Rani (2024), Vo <i>et al.</i> (2019), Kraus <i>et al.</i> (2020), Bassiouni <i>et al.</i> (2023)
7	Natural language processing (NLP)	Wichmann <i>et al.</i> (2018), Agarwal <i>et al.</i> (2024), Mah <i>et al.</i> (2022), Mohapatra <i>et al.</i> (2021), Zhou <i>et al.</i> (2021)
Source(s): Authors' compilation		

interacting intelligent agents (Helo and Rouzafzoon, 2023; Helo *et al.*, 2018; Holzfeind *et al.*, 2021; Lohmer *et al.*, 2020; Rouzafzoon and Helo, 2016). The GA technique is admired in the form of an equation that can assist to select the fittest individuals from the population to reproduce the behavior (Babaeinesami *et al.*, 2022; Min, 2015; Sayed Saif-Eddine *et al.*, 2019; Kannan *et al.*, 2010; Katoch *et al.*, 2021). An ES is admired in the form of a logical program that can help to simulate the actions of a human in a particular situation (Errasti *et al.*, 2010; Jin and Rong, 2011; Ernest *et al.*, 2010; Jędrzejczyński and Robak, 2010). The ANN system or model endures its existence by making interconnected nodes, called neurons, which process information by transmitting signals to each other to predict behaviors (Chiu and Lin, 2004; Meidute-Kavaliauskiene *et al.*, 2022; Soori *et al.*, 2023; Abdallah *et al.*, 2022; Biswas *et al.*, 2019). The BD techniques demonstrate the application of specialized procedure to analyze, interpret, and derive actionable insights from large and complex datasets to predict (Zamani *et al.*, 2022; Koot *et al.*, 2021; Addo-Tenkorang and Helo, 2016; Dubey *et al.*, 2019; Gunasekaran *et al.*, 2017; Hopkins and Hawking, 2018). DL is inspired by the structuring the system and its function in the form of human brain (Khedr and Rani, 2024; Vo *et al.*, 2019; Kraus *et al.*, 2020; Bassiouni *et al.*, 2023). NLP is concerned with giving computers the ability to understand, interpret, and generate human language (Wichmann *et al.*, 2018; Agarwal *et al.*, 2024; Mah *et al.*, 2022; Mohapatra *et al.*, 2021; Zhou *et al.*, 2021). In the present study, aforesaid techniques are presented in one roof for declaring their potential power for handing SCM activities and statics. The study attempts to describe the method and techniques that can be implemented under the domain of SCM to import self-thinking capability and to induce decision-making power for smartness.

The various support tools, i.e. ABS, GA, ES, ANN system, BD, DL and NLP conception, are identified from the literatur studies, which are discussed in this study for estimating their importance in handling the correct SCM activity. The pictorial representation of various capillary tools to support in transforming SCM into SSCM is presented in Figure 2. The present study will lead to present a surface picture with the methodological intension:

- (1) To map out the entire body of knowledge (literature review) under the streams of SCM and support tools that can provide self-thinking capabilities and DM power that has been documented, followed by

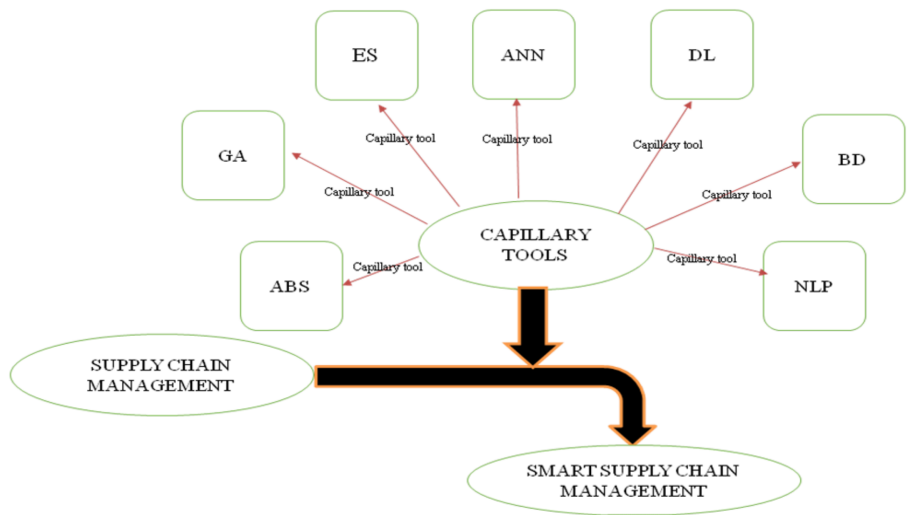


Figure 2. Pictorial representation of capillary tools towards transforming SCM into SSCM. Source: Authors’ compilation

- (2) A thorough discussion to interpret the overall pictorial representation of assets that can be merged to extend the boundaries of SCM into SSCM to create an understanding about “Which methodologies can be predominantly accepted for which field”.

The said tools are discussed to help practitioners in making an integrated framework for the evaluation of SSCM. By studying, competent studies, it has been found that many tools can be used in SCM to help in managing SCM stages related with maintaining of inventory levels, predicting customer demands, planning of supplies patterns, and optimization of transportation routes to compose real-time decisions to drive operational excellence, but that demands understandability of diverse tools, which is presented in this study. The intention of the study is to present capillary tools for SSCM design based foundation for future research. The pictorial representation of the intention of the study can be identified from Figure 3, where one can understand that the SC processes should be augmented and changed with the injection of DM tools to become more sustainable. The aforesaid can help in estimating the growing environmental challenges. The same are needed to draft intelligent and to prepare a less complex decision support framework and a novel approach for solving DM problems. Thus, one can understand that the system, where already decision support framework are integrated needs to be re-engineered, re-made and re-designed considering the components and complements of power tools towards improved decision-making.

3.1 DM tools to reinforce SCM thinking capabilities

Figure 2 represented various capillary tools that can be used to embed a multi-dimensional self-thinking DM network for automated planning of stuffs and to embrace human–artificial collaboration in SCM. The same will help to visualize, optimize and improve network orchestration with a level of efficiency that cannot be achieved with human thinking alone. Hence, the implications of capillary tools are discussed in this study to promote a deeper understanding about the capabilities of support tools that can be implemented in variants of SCM activities.

The authors outlined Figure 4 to represent the various capillary tools and their potential that can be used for implication in the theoretical portfolio of SCM for transforming it into SSCM. Here, SCM activities and capillary tools implication are presented in a single window in

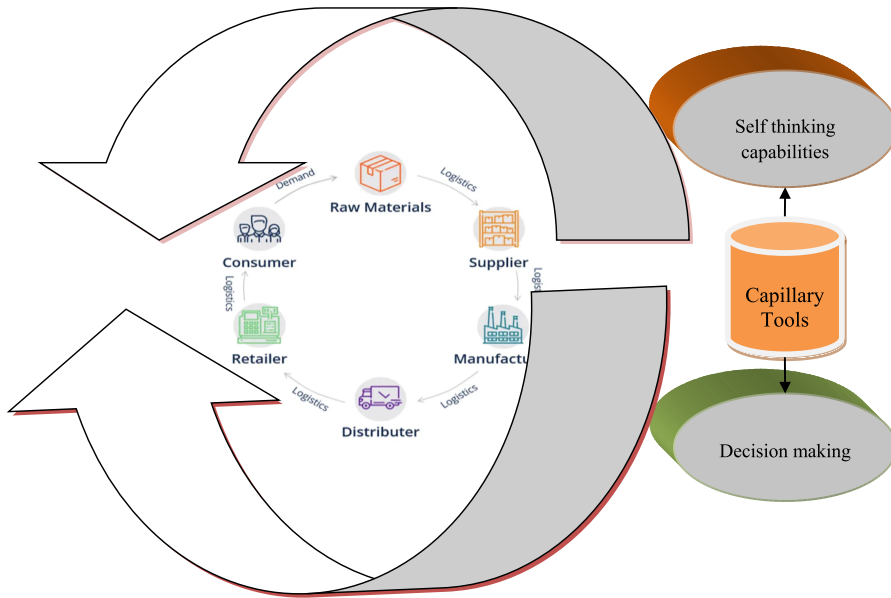


Figure 3. Pictorial representation of SCM structure posing requirements of DM tools. Source: Authors' compilation

Figure 4 to create an understandability of distinguished features that should be handled by capillary tools under SCM. The representation shown in Figure 4 admired the utility and implication of various support tools, whose pictorial representation is presented in Figure 2 towards transforming SCM into SSCM. Here, ABS is admired as a computational system that is composed of multiple interacting intelligent agents. These agents are autonomous entities that can perceive their environment, make decisions and take actions to achieve their goals (Helo *et al.*, 2018; Holzfeind *et al.*, 2021; Lohmer *et al.*, 2020). The GA is admired in the form of tool that can assist to select the fittest individuals from the population to reproduce. This is typically done using a fitness function, which assigns a score to each individual based on how well it solves the problem (Min, 2015; Sayed Saif-Eddine *et al.*, 2019; Kannan *et al.*, 2010). An ES is admired in the form of a computer program that simulates the DM and actions of a human expert in a particular field. Expert systems are typically admired by the authors to solve complex problems that require a high level of knowledge and expertise (Jin and Rong, 2011; Ernest *et al.*, 2010).

Here, ANN, which is a type of machine learning algorithm that is inspired by the structure and function of the human brain. ANNs endures its existence by making interconnected nodes, called neurons, which process information by transmitting signals to each other (Meidute-Kavaliauskiene *et al.*, 2022; Soori *et al.*, 2023; Abdallah *et al.*, 2022). ANNs are found trained on analyzing data by adjusting the weights of the connections between the neurons. ANN iterative framework minimizes the error between the network's output and the desired output. Once trained, ANNs can be used to make predictions or decisions on new data. Additionally, the study has admired BD techniques as the application of specialized techniques to analyze, interpret, and derive actionable insights from large and complex datasets (Koot *et al.*, 2021; Addo-Tenkorang and Helo, 2016; Dubey *et al.*, 2019). The BD has the potential to revolutionize various industries by enabling businesses to make more informed decisions, improve operational efficiency and identify new opportunities for growth.

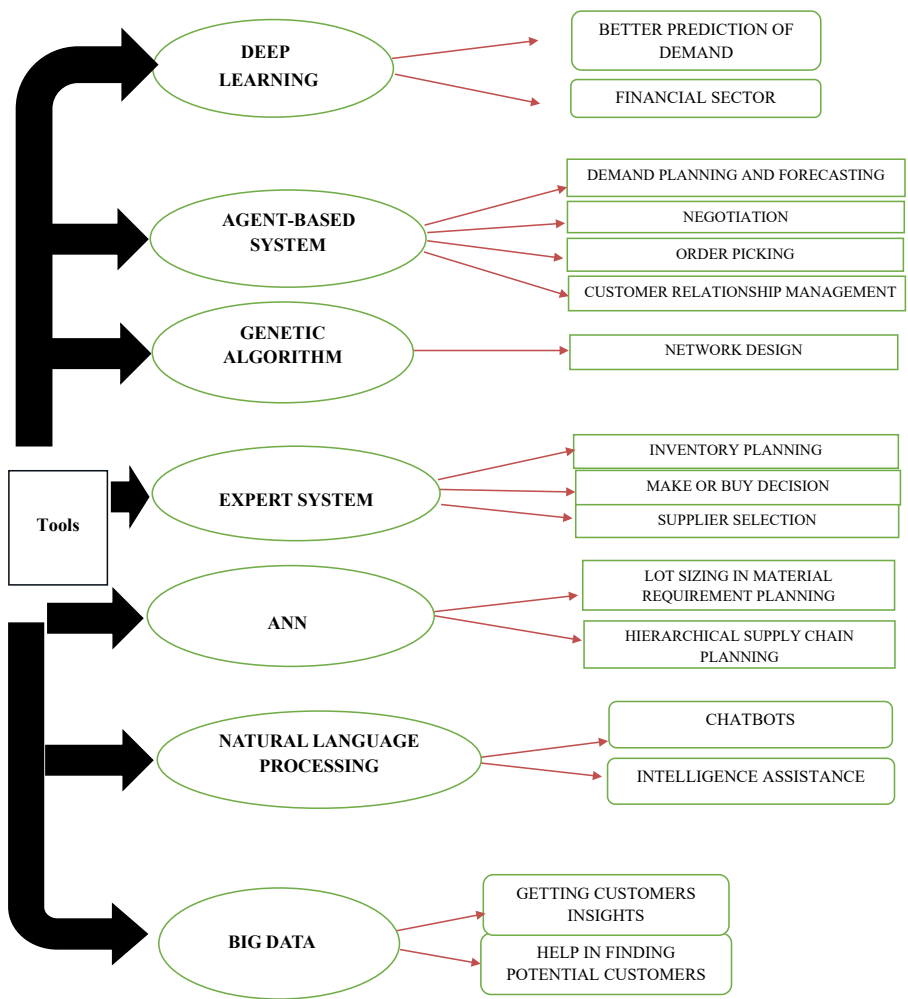


Figure 4. Pictorial representation of DM tools to reinforce SCM thinking capabilities. Source: Authors' compilation

Moreover; DL is admired as a subset of machine learning that is inspired by the structure and function of the human brain (Vo *et al.*, 2019; Kraus *et al.*, 2020; Bassiouni *et al.*, 2023). It uses ANNs to learn from large amounts of data, without the need for explicit programming. NLP can be used to deal with the interaction between computers and human language. It is concerned with giving computers the ability to understand, interpret and generate human language (Agarwal *et al.*, 2024; Mah *et al.*, 2022; Mohapatra *et al.*, 2021). The various variants that can craft intelligent and self-thinking capabilities are represented in Figure 4 along with SCM activity and are discussed in Section 5.

4. Implications and deliberations

In this section, the authors have presented various theories related to the capillary tools that can help in renovating traditional SC into self-thinking SC, i.e. Smart SCM. Here, in this section,

various support tools, i.e. ABS, GA, ES, ANN system, BD, DL and NLP conception, are discussed with SCM activity for proposing their implication. The same are discussed to enrich the knowledge of the practitioners and to highlight the utility of capillary elements for strengthening SCM.

4.1 Capillary tool elements

The tabulation and description of capillary tool elements under the specific extent of SC activity can be identified from Table 2. It is affirmed that the various decision-making elements presented in Figure 4 can stimulate SC structure in the form of human brain and can be employed under distinguish SC activities to react in uncertain decision situation based on the reception of the huge amounts of data. The study affirmed that the capillary tools can be used to exploit information based on the arrangements of multiple layers of customer's nodes, uses, search and so on, which process and transform information.

4.2 Discussions and practical implications of the research findings

The capillary tools presented in this study can be used for indeed modeling by the manufacturers and concerns to identify multifaceted customer, supplier and retailer patterns in the form of pictures, text, sounds, and other forms of data to reproduce precise insights and forecasts. One can employ capillary tools to automate a task that typically needs human intelligence for describing images or writing out a sound into text. The same can be employed to iteratively educate computers to think, discover and learn like humans. The study affirmed that the principal integration of ANN in SCM can award benefits in determining lot sizing in material requirement planning and can be used to successfully sketch hierarchical SC planning. Here, ANN can be used to decide the optimal lot size under discrete time periods of multiple items over time. The same can lead to planning demand patterns with minimization of ordering and inventory carrying costs. Additionally, the ANN in SC can be used to decompose complex tasks into simpler sub-tasks based on framing of hierarchical structures and task networks. ANN can be used to decide sub-tasks, which can be further decomposed into primitive actions that can be directly executed. ANN can analyze complex SC relationships and patterns with the representation of data into structural nodes and neurons.

Agent-based system (ABS) can be used in SC towards demand planning and its forecasting, negotiation, order picking and making delightful customer relationship. ABS based on the collection of historical demand data, machine data, resources data and applied managerial strategies build a rule-based prediction for demand management in SCM. ABS can be used to evaluate on-line bids, on-line purchase orders, which thereby can endeavors ability over the SC to negotiate the SC stuffs up to elevated zones. ABS can evaluate with different combinations of routing policies, warehousing and can assist in planning the paramount arrangements towards multiple order pickers in multiple storage areas. Deploys of intelligent agents in ABS modeling can facilitate in mapping, supplier-buyer collaboration, expectations and detainments amongst SC.

The principal integration of GA in SCM can award benefits in assuming network design and optimization of inventories. GA can be used to optimally design the logistic and supplier network under an SC with the determination of multiple criteria. GA models can assure the maintenance of excess stock levels and can indicate the numeral need of a specific entity and shortage level, which can escort inventory optimization model in SC. Moreover, DM elements allied with the deployment of ES can help in inventory planning, make or buy decision, supplier selection and management of human resources. ES in SC can be used to prepare a rule from the attainments of SC to make decisions concerning with practical inventory management, declaration of new resources, market dynamics, turbulence, future growth and productivity gains. An ES in SC can be used to collect, transform and store organizational knowledge towards the formulation of marketing means, tangible resources, logistics activities and reverse logistics strategy. ES can assist in choosing the supplier as per the

Table 2. Tabulation and description of various capillary tools to reinforce SCM capabilities

Problem scope	Methodology	Discussion
<i>Contribution of ANN in SCM</i>		
Lot sizing in material requirement planning	ANN	ANN can be used to determine the optimal attainments of lot size considering discrete time periods of multiple items over time periods. The same can assists to satisfy a certain demand pattern, under the objective of minimization of the sum of ordering and inventory carrying costs. ANN modeling can be a fruitful choice towards identifying robust decisions related with the changing demand patterns over time periods
Hierarchical SC planning	ANN	The completion of high level tasks demands their decomposition into simpler sub-tasks based on the utilization of hierarchical structures called task networks. ANN can lead in dividing a complex task into smaller and more manageable sub-task, where; sub-tasks can be further decomposed into primitive actions that can be directly executed. ANN can out-perform its existence under said field by exemplifying an approach towards representing and analyzing complex relationships and patterns within data
<i>Contribution of ABS in SCM</i>		
Demand planning and forecasting	Agent-based system	ABS can be used under the custody of planning demands and it's forecasting, where; based on the collection of historical demand data, machine data, resources data and applied managerial strategies; ABS can build a rule-based prediction for demand management in SCM.
Negotiation	Agent-based system	ABS can be combined with a knowledge-based system to issue requests for quotations, evaluation of on-line bids, and automation of on-line purchase orders, which; thereby can craft the characteristics of negotiating the stuffs up-to elevated zones. The ABS can pull the knowledge bases of experienced purchasing professionals to automate e-procurement processes
Order picking	Agent-based system	ABS can help in the process of collecting items from a warehouse to complete customer orders. ABS can evaluate different combinations of routing policies and can assist in planning the best arrangements related to multiple order pickers in multiple storage areas
Customer relationship management	Agent-based system	ABS deploys intelligent agents in its modeling, which facilitated in mapping, supplier-buyer collaboration, expectations and detainments amongst a SC. Intelligent agents can use a web-based technology for the attainment of data and SC integration
<i>Contribution of GA in SCM</i>		
Network design	Genetic algorithm	GA can be used to optimally design the transportation network under a SC, where; multiple criteria's can be considered under GA based algorithm to reduce the necessity of number of transportation means
Inventory optimization	Genetic algorithm	GA can be used to characteristically determine the most likely excess stock level, need of a specific entity and shortage level; which can lead in building inventory optimization model in SC with the objective of minimization of the total supply chain cost

(continued)

Table 2. Continued

Problem scope	Methodology	Discussion
<i>Contribution of ES in SCM</i>		
Inventory planning	Expert system	A rule-based expert system can be used under the origins of SC to assist in making decisions involving with practical inventory management, declaration of new resources, market dynamics, turbulence and future growth. The ES in SCM can lead to productivity gains
Make or buy decision	Expert system	An ES provisions can be used in SC to collect, transform, and store organizational knowledge towards the formulation of marketing means, tangible resources, logistics activities and reverse logistics strategy. ES can incorporate case-based reasoning into data mining techniques to facilitate the strategy development process
Supplier selection	Expert system	The supplier base can improve the efficiency and credibility of the SC, where an ES can utilize a case-based reasoning approach to smooth the progress of choosing the supplier as per the designated attributes required under a scenario
<i>Contribution of DL in SCM</i>		
Prediction of demand	Deep Learning	Deep Learning traits based on the gathering of information on consumer behavior, route planning, economic indicators, intermediates and competitor analysis can lead in making accurate projection of demand and activity forecasts. The historical sales data, seasonal trends, combination of historical data with market trends, customer insights, and external factors can help in the generation of demand forecasts related with different variants of products, regions, and time-frames
Financial sector	Deep learning	Deep learning models can use learned patterns and financial results of documents to estimate in analyzing the credit risks, customer's behaviors and loan requests. The data related with income, occupation, age, current financial assets, current credit scores, overdrafts, outstanding balance, foreclosures, loan payments can be used under DL to project a financial need and requirements
<i>Contribution of BD in SCM</i>		
Receiving customers insights	Big data	BD can analyze unstructured information statistics in the vein of images, videos and voice recordings that are collected from customer interactions. Here, BD can assist in reveling such details towards determining subconscious preferences, determination of addicts, explanation of priorities, cultural gradation and promising trends. BD can help in explanation the above said from the data collected from surveys or focus groups and its avoidance can completely miss-understood the attainment of objectives
Ruling potential customers	Big data	The implication of BD can help in identifying and ruling towards potential customers. The BD analysis of collected data from the regular clients visit, web visits, call logs, social networks and any other available sources can assist in ruling towards potential customers based on amplification of the speed and quality of the interaction by each passing day, by solving issues pro-actively and generating personalized offers and supports

(continued)

Table 2. Continued

Problem scope	Methodology	Discussion
<i>Contribution of NLP in SCM</i> Supply chain chatbots	Natural language processing	NLP can help in preparing SC chatbots, which can impose elevated abilities including recognition of consumer's intention, which allows SC chatbots to categorize the input, demands and to determine about user interest and wants. The same will help in identifying part and piece of elements. Chatbots scan and examine text and identify elementary entities
Intelligence assistance	Natural language processing	NLP is a sub-set towards crafting AI, which can facilitate Chatbots to recognize languages, activities and speak performed by humans. The same can help in understanding the intention of client's questions, which thereby can lead in enduring intelligence to system and its characteristics. They group real-world objects like people, places, or businesses before classifying them into categories

Source(s): Authors' compilation

designated attributes required under a scenario. It is highlighted that ES can help in rule based decision modeling under SC to assist in decisions related with practical inventory management, declaration of new resources, market dynamics, turbulence and future growth. ES can be used in SC to collect, transform and store organizational knowledge towards the formulation of marketing means, tangible resources, logistics activities and reverse logistics strategy. ES can help in choosing the supplier as per the designated attributes required under a scenario.

It is further declared that DL can be used to predict demand and financial patterns based on information from consumer behavior, route planning, economic indicators, intermediates and competitor analysis, which can help in accrediting accurate projection of demand and activity forecasts. Here, the historical sales data, seasonal trends, combination of historical data with market trends, customer insights and external factors can help in the generation of demand forecasts and data related with income, occupation, age, current financial assets, current credit scores, overdrafts, outstanding balance, foreclosures, loan payments can be used to project a financial need and requirements. Additionally, the utility of BD is also highlighted in the study to help in identifying and solving issues allied with potential customers. The BD analysis of collected data from the regular clients visit, web visits, call logs, social networks and any other available sources can assist in ruling towards potential customers based on amplification of the speed and quality of the interaction. Moreover, it is affirmed that NLP can also be used in SC towards preparing SC chatbots and building intelligence based on recognition of consumer intention from SC chatbots. The same can help in understanding the intention of clients' questions, which thereby can lead in enduring intelligence to system and its characteristics.

5. Conclusions

In the present study, the authors provided a widespread impression of diverse DM capillary tools that can be used to handle widespread stream of SCM activities to make it more sustainable. The study presented a surface picture and representation of capillary tools to reinforce SCM-DM-capabilities for the transformation into SSCM. The study mapped out the entire body of knowledge under the sphere of literature review considering streams of SCM and capillary tools allied with providing self-thinking capabilities and DM power, which can

help practitioners in making an integrated framework for the evaluation of SSCM. The findings of the study presented that the capabilities that can impart intelligence is the need of today's scenario to evade resilient and to handle mismanagement of scenario and situations. The study presented a thorough discussion of various support tools, i.e. ABS, GA, ES, ANN, BD, DL and NLP and their estimation to be implicated for handling the correct SCM activity. The study advocated that these tools can create alerts and informs users about the true need of concerns and the integration of these tools can lead in forecasting prospects under the roof of identification of target customers, demography, defining the price, designing the right message and providing their customers a better experience, which can help in leading towards evading SC troubles. A thorough investigation to interpret the overall pictorial representation of DM assets is presented in the study that can be used to extend the boundaries of SCM into SSCM and to create understandability about which methodologies can be predominantly accepted under which SCM activity. The same will help practitioners in mounting SCM operations with self-thinking intelligence under the aspects of maintaining inventory levels, predicting customer demands, planning of supplies patterns and optimization of transportation routes. The study will assist in composing real-time decisions towards driving operational excellence.

References

- Abdallah, A., Dauwed, M., Aly, A.A., Felemban, B.F., Khan, I. and Choi, B.J. (2022), "An optimal method for supply chain logistics management based on neural network", *CMC-Computers, Materials and Continua*, Vol. 73, pp. 4311-4327.
- Addo-Tenkorang, R. and Helo, P.T. (2016), "Big data applications in operations/supply chain management: a literature review", *Computers and Industrial Engineering*, Vol. 101, pp. 528-543, doi: [10.1016/j.cie.2016.09.023](https://doi.org/10.1016/j.cie.2016.09.023).
- Agarwal, P., Malhotra, S.K. and Swami, S. (2024), "The role of smart technologies in managing supply chain post pandemic: an exploratory scientific procedures and rationales for systematic literature review", *Journal of Science and Technology Policy Management*, Vol. 16 No. 4, pp. 706-732, doi: [10.1108/JSTPM-07-2023-0106](https://doi.org/10.1108/JSTPM-07-2023-0106).
- Ahmadi, T., Hesarakhi, A.F. and Morsch, J.P.M. (2025), "Exploring IT-driven supply chain capabilities and resilience: the roles of supply chain risk management and complexity", *Supply Chain Management*, Vol. 30 No. 1, pp. 50-66, doi: [10.1108/SCM-11-2023-0561](https://doi.org/10.1108/SCM-11-2023-0561).
- Ahmed, K.A., Sahu, A.K., Sahu, A.K. and Sahu, N.K. (2022), "Quantify the behaviour intention of individuals to control SC performance by exploring cloud storage services: an extended UTAUT2 approach", *International Journal of Technology and Human Interaction*, Vol. 18 No. 7, pp. 1-28, doi: [10.4018/ijthi.306227](https://doi.org/10.4018/ijthi.306227).
- Babaeinesami, A., Ghasemi, P., Chobar, A.P., Sasouli, M.R. and Lajevardi, M. (2022), "A new wooden supply chain model for inventory management considering environmental pollution: a genetic algorithm", *Foundations of Computing and Decision Sciences*, Vol. 47 No. 4, pp. 383-408, doi: [10.2478/fcds-2022-0027](https://doi.org/10.2478/fcds-2022-0027).
- Bag, S., Pretorius, J.H.C., Gupta, S. and Dwivedi, Y.K. (2021), "Role of institutional pressures and resources in the adoption of big data analytics powered artificial intelligence, sustainable manufacturing practices, and circular economy capabilities", *Technological Forecasting and Social Change*, Vol. 163, 120420, doi: [10.1016/j.techfore.2020.120420](https://doi.org/10.1016/j.techfore.2020.120420).
- Baryannis, G., Validi, S., Dani, S. and Antoniou, G. (2018), "Supply chain risk management and artificial intelligence: state of the art and future research directions", *International Journal of Production Research*, Vol. 57 No. 7, pp. 2179-2202, doi: [10.1080/00207543.2018.1530476](https://doi.org/10.1080/00207543.2018.1530476).
- Bassiouni, M.M., Chakraborty, R.K., Hussain, O.K. and Rahman, H.F. (2023), "Advanced deep learning approaches to predict supply chain risks under COVID-19 restrictions", *Expert Systems with Applications*, Vol. 211, 118604, doi: [10.1016/j.eswa.2022.118604](https://doi.org/10.1016/j.eswa.2022.118604).
- Baycik, N.O. and Gowda, S. (2024), "Digitalization of operations and supply chains: insights from survey and case studies", *Digital Transformation and Society*, Vol. 3 No. 3, pp. 277-295, doi: [10.1108/DTS-09-2023-0087](https://doi.org/10.1108/DTS-09-2023-0087).

- Benzidia, S., Makaoui, N. and Bentahar, O. (2021), "The impact of big data analytics and artificial intelligence on green supply chain process integration and hospital environmental performance", *Technological Forecasting and Social Change*, Vol. 165, 120557, doi: [10.1016/j.techfore.2020.120557](https://doi.org/10.1016/j.techfore.2020.120557).
- Biswas, S., Anavatti, S.G. and Garratt, M.A. (2019), "Multiobjective mission route planning problem: a neural network-based forecasting model for mission planning", *IEEE Transactions on Intelligent Transportation Systems*, Vol. 22, pp. 430-442, doi: [10.1109/TITS.2019.2949492](https://doi.org/10.1109/TITS.2019.2949492).
- Calatayud, A., Mangan, J. and Christopher, M. (2019), "The self-thinking supply chain", *Supply Chain Management: International Journal*, Vol. 24 No. 1, pp. 22-38, doi: [10.1108/scm-03-2018-0136](https://doi.org/10.1108/scm-03-2018-0136).
- Canhoto, A.I. and Clear, F. (2020), "Artificial intelligence and machine learning as business tools: a framework for diagnosing value destruction potential", *Business Horizons*, Vol. 63 No. 2, pp. 183-193, doi: [10.1016/j.bushor.2019.11.003](https://doi.org/10.1016/j.bushor.2019.11.003).
- Chiu, M. and Lin, G. (2004), "Collaborative supply chain planning using the artificial neural network approach", *Journal of Manufacturing Technology Management*, Vol. 15 No. 8, pp. 787-796, doi: [10.1108/17410380410565375](https://doi.org/10.1108/17410380410565375).
- Diaz, R., Smith, K., Acero, B., Longo, F. and Padovano, A. (2021), "Developing an artificial intelligence framework to assess shipbuilding and repair sub-tier supply chains risk", *Procedia Computer Science*, Vol. 180, pp. 996-1002, doi: [10.1016/j.procs.2021.01.363](https://doi.org/10.1016/j.procs.2021.01.363).
- Dirican, C. (2015), "The impacts of robotics, artificial intelligence on business and economics", *Procedia – Social and Behavioral Sciences*, Vol. 195, pp. 564-573, doi: [10.1016/j.sbspro.2015.06.134](https://doi.org/10.1016/j.sbspro.2015.06.134).
- Dubey, R., Gunasekaran, A. and Childe, S.J. (2019), "Big data analytics capability in supply chain agility: the moderating effect of organizational flexibility", *Management Decision*, Vol. 57 No. 8, pp. 2092-2112, doi: [10.1108/MD-01-2018-0119](https://doi.org/10.1108/MD-01-2018-0119).
- Ernest, A., Fattic, J., Chang, N.B., Chitrapu, S. and Davenport, P. (2010), "WRmt case study: GIS with rule-based expert system for optimal planning of sensor network in drinking water systems", *ASCE Annual Conference and Exposition, Louisville, 2010*, Washington, DC, American Society for Engineering Education (ASCE), pp. 1-9.
- Errasti, A., Chackelson, C. and Poler, R. (2010), "An expert system for inventory replenishment optimization", in Ortiz, Á., Franco, R.D. and Gasquet, P.G. (Eds), *Balanced Automation Systems for Future Manufacturing Networks*, Springer, Berlin, Heidelberg, Vol. 322, pp. 123-130, doi: [10.1007/978-3-642-14341-0_15](https://doi.org/10.1007/978-3-642-14341-0_15).
- Foo, P.Y., Lee, V.H., Tan, G.W.H. and Ooi, K.B. (2018), "A gateway to realising sustainability performance via green supply chain management practices: a PLS-ANN approach", *Expert Systems with Applications*, Vol. 107, pp. 1-14, doi: [10.1016/j.eswa.2018.04.013](https://doi.org/10.1016/j.eswa.2018.04.013).
- Gunasekaran, A., Papadopoulos, T., Dubey, R., Wamba, S.F., Childe, S.J., Hazen, B. and Akter, S. (2017), "Big data and predictive analytics for supply chain and organizational performance", *Journal of Business Research*, Vol. 70, pp. 308-317, doi: [10.1016/j.jbusres.2016.08.004](https://doi.org/10.1016/j.jbusres.2016.08.004).
- Haenlein, M. and Kaplan, A. (2019), "A brief history of artificial intelligence: on the past, present, and future of artificial intelligence", *California Management Review*, Vol. 61 No. 4, pp. 5-14, doi: [10.1177/0008125619864925](https://doi.org/10.1177/0008125619864925).
- Hartley, J.L. and Sawaya, W.J. (2019), "Tortoise, not the hare: digital transformation of supply chain business processes", *Business Horizons*, Vol. 62 No. 6, pp. 707-715, doi: [10.1016/j.bushor.2019.07.006](https://doi.org/10.1016/j.bushor.2019.07.006).
- Helo, P. and Rouzafzoon, J. (2023), "An agent-based simulation and logistics optimization model for managing uncertain demand in forest supply chains", *Supply Chain Analytics*, Vol. 4, 100042, doi: [10.1016/j.sca.2023.100042](https://doi.org/10.1016/j.sca.2023.100042).
- Helo, P., Rouzafzoon, J. and Gunasekaran, A. (2018), "Service supply chain design by using agent-based simulation", in Kohtamäki, M., Baines, T., Rabetino, R. and Bigdeli, A.Z. (Eds), *Practices and Tools for Servitization: Managing Service Transition*, Springer International Publishing, pp. 387-403, doi: [10.1007/978-3-319-76517-4_23](https://doi.org/10.1007/978-3-319-76517-4_23).

- Holzfeind, T., Kanzian, C. and Gronalt, M. (2021), "Challenging agent-based simulation for forest operations to optimize the European cable yarding and transport supply chain", *International Journal of Forest Engineering*, Vol. 32 No. 1, pp. 77-90, doi: [10.1080/14942119.2021.1876372](https://doi.org/10.1080/14942119.2021.1876372).
- Hopkins, J. and Hawking, P. (2018), "Big data analytics and IoT in logistics: a case study", *International Journal of Logistics Management*, Vol. 29 No. 2, pp. 575-591, doi: [10.1108/IJLM-05-2017-0109](https://doi.org/10.1108/IJLM-05-2017-0109).
- Hu, M., Jiang, S. and Huo, B. (2024), "The impacts of supply visibility and demand visibility on product innovation: the mediating role of supply chain integration", *International Journal of Logistics Management*, Vol. 35 No. 2, pp. 456-482, doi: [10.1108/IJLM-01-2021-0033](https://doi.org/10.1108/IJLM-01-2021-0033).
- Isabel, A. (2015), "The impacts of robotics, artificial intelligence on business and economics", *Procedia - Social and Behavioral Sciences*, Vol. 195, pp. 564-573, doi: [10.1016/j.sbspro.2015.06.134](https://doi.org/10.1016/j.sbspro.2015.06.134).
- Jauhar, S.K., Jani, S.M., Kamble, S.S., Pratap, S., Belhadi, A. and Gupta, S. (2023), "How to use no-code artificial intelligence to predict and minimize the inventory distortions for resilient supply chains", *International Journal of Production Research*, Vol. 62 No. 15, pp. 1-25, doi: [10.1080/00207543.2023.2166139](https://doi.org/10.1080/00207543.2023.2166139).
- Jędrzejczyński, A. and Robak, S. (2010), "Application of an expert system for some logistic problems", in Rutkowski, L., Scherer, R., Tadeusiewicz, R., Zadeh, L.A. and Zurada, J.M. (Eds), *Artificial Intelligence and Soft Computing*, Springer, Berlin, Heidelberg, Vol. 6114, pp. 647-654, doi: [10.1007/978-3-642-13232-2_77](https://doi.org/10.1007/978-3-642-13232-2_77).
- Jiang, S., Yeung, A.C.L., Han, Z. and Huo, B. (2023), "The effect of customer and supplier concentrations on firm resilience during the COVID-19 pandemic: resource dependence and power balancing", *Journal of Operations Management*, Vol. 69 No. 3, pp. 497-518, doi: [10.1002/joom.1236](https://doi.org/10.1002/joom.1236).
- Jin, C. and Rong, W. (2011), "Modeling of expert system of quality standard in supply chain", *Robotics and Computer-Integrated Manufacturing*, Vol. 27 No. 1, pp. 56-61, doi: [10.1016/j.rcim.2010.06.002](https://doi.org/10.1016/j.rcim.2010.06.002).
- Kannan, G., Sasikumar, P. and Devika, K. (2010), "A genetic algorithm approach for solving a closed-loop supply chain model: a case of battery recycling", *Applied Mathematical Modelling*, Vol. 34 No. 3, pp. 655-670, doi: [10.1016/j.apm.2009.06.021](https://doi.org/10.1016/j.apm.2009.06.021).
- Katoch, S., Chauhan, S.S. and Kumar, V. (2021), "A review on genetic algorithm: past, present, and future", *Multimedia Tools and Applications*, Vol. 80 No. 6, pp. 8091-8126, doi: [10.1007/s11042-020-10139-6](https://doi.org/10.1007/s11042-020-10139-6).
- Khedr, A.M. and Rani, S.S. (2024), "Enhancing supply chain management with deep learning and machine learning techniques: a review", *Journal of Open Innovation: Technology, Market, and Complexity*, Vol. 10 No. 4, 100379, doi: [10.1016/j.joitmc.2024.100379](https://doi.org/10.1016/j.joitmc.2024.100379).
- Klumpp, M. (2018), "Automation and artificial intelligence in business logistics systems: human reactions and collaboration requirements", *International Journal of Logistics Research and Applications*, Vol. 21 No. 3, pp. 224-242, doi: [10.1080/13675567.2017.1384451](https://doi.org/10.1080/13675567.2017.1384451).
- Koot, M., Mes, M.R.K. and Iacob, M.E. (2021), "A systematic literature review of supply chain decision making supported by the Internet of Things and big data analytics", *Computers and Industrial Engineering*, Vol. 154, 107076, doi: [10.1016/j.cie.2020.107076](https://doi.org/10.1016/j.cie.2020.107076).
- Kottala, S.Y. and Sahu, A.K. (2023), "Evaluating ergonomics and financial distress in manufacturing organization behavior: resiliency framework from operations and strategic management", in *The Learning Organization*, Advance online publication, doi: [10.1108/TLO-03-2023-0041](https://doi.org/10.1108/TLO-03-2023-0041).
- Kraus, M., Feuerriegel, S. and Oztekin, A. (2020), "Deep learning in business analytics and operations research: models, applications and managerial implications", *European Journal of Operational Research*, Vol. 281 No. 3, pp. 628-641, doi: [10.1016/j.ejor.2019.09.018](https://doi.org/10.1016/j.ejor.2019.09.018).
- Lerman, L.V., Benitez, G.B., Müller, J.M., de Sousa, P.R. and Frank, A.G. (2022), "Smart green supply chain management: a configurational approach to enhance green performance through digital transformation", *Supply Chain Management*, Vol. 27 No. 7, pp. 147-176, doi: [10.1108/SCM-02-2022-0059](https://doi.org/10.1108/SCM-02-2022-0059).

- Li, N., Prabhu, M. and Sahu, A.K. (2023), "Investigating economic replacement policy under uncertainty for managerial application based on grey-reliability approach using QCC", *Grey Systems: Theory and Application*, Vol. 13 No. 2, pp. 297-321, doi: [10.1108/GS-07-2022-0075](https://doi.org/10.1108/GS-07-2022-0075).
- Li, P., Chen, Y. and Guo, X. (2025), "Digital transformation and supply chain resilience", *International Review of Economics and Finance*, Vol. 99, 104033, doi: [10.1016/j.iref.2025.104033](https://doi.org/10.1016/j.iref.2025.104033).
- Lohmer, J., Bugert, N. and Lasch, R. (2020), "Analysis of resilience strategies and ripple effect in blockchain-coordinated supply chains: an agent-based simulation study", *International Journal of Production Economics*, Vol. 228, 107882, doi: [10.1016/j.ijpe.2020.107882](https://doi.org/10.1016/j.ijpe.2020.107882).
- Mah, P.M., Skalna, I. and Muzam, J. (2022), "Natural language processing and artificial intelligence for enterprise management in the era of Industry 4.0", *Applied Sciences*, Vol. 12 No. 18, p. 9207, doi: [10.3390/app12189207](https://doi.org/10.3390/app12189207).
- Martinčević, I., Sesar, V. and Globočnik Žunac, A. (2021), "Artificial intelligence and blockchain—new challenges for digital supply chain management", *Proceedings of the 21st International Scientific Conference on Business Logistics in Modern Management*, Osijek, Croatia.
- Massari, G.F., Naccchio, R. and Giannoccaro, I. (2025), "Transformative supply chains: the enabling role of digital technologies", *International Journal of Production Economics*, Vol. 283, 109562, doi: [10.1016/j.ijpe.2025.109562](https://doi.org/10.1016/j.ijpe.2025.109562).
- Meidute-Kavaliauskienė, I., Taşkın, K., Ghorbani, S., Činčikaitė, R. and Kačenauskaitė, R. (2022), "Reviewing the applications of neural networks in supply chain: exploring research propositions for future directions", *Information (Basel)*, Vol. 13 No. 5, p. 261, doi: [10.3390/info13050261](https://doi.org/10.3390/info13050261).
- Min, H. (2010), "Artificial intelligence in supply chain management: theory and applications", *International Journal of Logistics Research and Applications*, Vol. 13 No. 1, pp. 13-39, doi: [10.1080/13675560902736537](https://doi.org/10.1080/13675560902736537).
- Min, H. (2015), "Genetic algorithm for supply chain modelling: basic concepts and applications", *International Journal of Services and Operations Management*, Vol. 22 No. 2, pp. 143-164, doi: [10.1504/IJSOM.2015.070719](https://doi.org/10.1504/IJSOM.2015.070719).
- Min, S., Zacharia, Z.G. and Smith, C.D. (2019), "Defining supply chain management: in the past, present, and future", *Journal of Business Logistics*, Vol. 40 No. 1, pp. 44-55, doi: [10.1111/jbl.12201](https://doi.org/10.1111/jbl.12201).
- Mishra, D., Muduli, K., Raut, R., Narkhede, B.E., Shee, H. and Jana, S.K. (2023), "Challenges facing artificial intelligence adoption during COVID-19 pandemic: an investigation into the agriculture and agri-food supply chain in India", *Sustainability (Basel)*, Vol. 15 No. 8, p. 6377, doi: [10.3390/su15086377](https://doi.org/10.3390/su15086377).
- Modgil, S., Singh, R.K. and Hannibal, C. (2022), "Artificial intelligence for supply chain resilience: learning from Covid-19", *International Journal of Logistics Management*, Vol. 33 No. 4, pp. 1246-1268, doi: [10.1108/ijlm-02-2021-0094](https://doi.org/10.1108/ijlm-02-2021-0094).
- Mohapatra, K., Nayak, M. and Nayak, A.K. (2021), "Techniques behind smart home automation system using NLP and IoT", in *Green Technology for Smart City and Society*, Springer, pp. 105-115.
- Moleme, L.O., Omoruyi, O. and Quayson, M. (2024), "Supply chain visibility and integration in the age of the Internet of Things: a retail perspective", *Modern Supply Chain Research and Applications*, Vol. 6 No. 3, pp. 330-350, doi: [10.1108/MS CRA-08-2023-0035](https://doi.org/10.1108/MS CRA-08-2023-0035).
- Moraes, K.K., Ganga, G.M.D., Godinho Filho, M., Santa-Eulalia, L.A. and Tortorella, G.L. (2025), "Overcoming technological barriers for blockchain adoption in supply chains: a diffusion of innovation (DOI)-informed framework proposal", *Supply Chain Management*, Vol. 30 No. 1, pp. 19-49, doi: [10.1108/SCM-02-2024-0138](https://doi.org/10.1108/SCM-02-2024-0138).
- Nakabuye, Z., Mayanja, J., Bimbona, S. and Wassermann, M. (2023), "Technology orientation and export performance: the moderating role of supply chain agility", *Modern Supply Chain Research and Applications*, Vol. 5 No. 4, pp. 230-264, doi: [10.1108/MS CRA-01-2023-0006](https://doi.org/10.1108/MS CRA-01-2023-0006).
- Namagembe, S. and Mbago, M. (2023), "Small and medium enterprise agro-processing firms' supply chain performance: the role of owner-manager's managerial competencies, information sharing, and information quality", *Modern Supply Chain Research and Applications*, Vol. 5 No. 4, pp. 265-288, doi: [10.1108/MS CRA-11-2022-0033](https://doi.org/10.1108/MS CRA-11-2022-0033).

- Neugebauer, S., Rippitsch, L., Sobieczky, F. and Gei, M. (2021), "Explainability of AI-predictions based on psychological profiling", *Procedia Computer Science*, Vol. 180, pp. 1003-1012, doi: [10.1016/j.procs.2021.01.361](https://doi.org/10.1016/j.procs.2021.01.361).
- Ning, L. and Yao, D. (2023), "The impact of digital transformation on supply chain capabilities and supply chain competitive performance", *Sustainability (Basel)*, Vol. 15 No. 13, 10107, doi: [10.3390/su151310107](https://doi.org/10.3390/su151310107).
- Nishad, S., Sahu, A.K. and Sahu, N.K. (2024), "Advocating lean practices and strategies in decision-making for reinforcing industrial and manufacturing designs", in Sahu, A.K., Raut, R.D., Raja, R., Sahu, A.K. and Sahu, N.K. (Eds), *Industrial and Manufacturing Designs*, doi: [10.1002/9781394212668.ch3](https://doi.org/10.1002/9781394212668.ch3).
- Plastino, E. and Purdy, M. (2018), "Game changing value from artificial intelligence: eight strategies", *Strategy and Leadership*, Vol. 46 No. 1, pp. 16-22, doi: [10.1108/sl-11-2017-0106](https://doi.org/10.1108/sl-11-2017-0106).
- Pournader, M., Ghaderi, H., Hassanzadegan, A. and Fahimnia, B. (2021), "Artificial intelligence applications in supply chain management", *International Journal of Production Economics*, Vol. 241, 108250, doi: [10.1016/j.ijpe.2021.108250](https://doi.org/10.1016/j.ijpe.2021.108250).
- Ren, L., Zhou, Z., Fu, Y., Liu, A. and Ma, Y. (2024), "Integrated optimization of logistics routing problem considering chance preference", *Modern Supply Chain Research and Applications*, Vol. 6 No. 4, pp. 376-392, doi: [10.1108/MS CRA-05-2023-0016](https://doi.org/10.1108/MS CRA-05-2023-0016).
- Richter, L., Lehna, M., Marchand, S., Scholz, C., Dreher, A., Klaiber, S. and Lenk, S. (2022), "Artificial intelligence for electricity supply chain automation", *Renewable and Sustainable Energy Reviews*, Vol. 163, 112459, doi: [10.1016/j.rser.2022.112459](https://doi.org/10.1016/j.rser.2022.112459).
- Rodríguez-Espíndola, O., Chowdhury, S., Beltaoui, A. and Albores, P. (2020), "The potential of emergent disruptive technologies for humanitarian supply chains: the integration of blockchain, artificial intelligence and 3D printing", *International Journal of Production Research*, Vol. 58 No. 15, pp. 4610-4630, doi: [10.1080/00207543.2020.1761565](https://doi.org/10.1080/00207543.2020.1761565).
- Rouzafzoon, J. and Helo, P. (2016), "Developing service supply chains by using agent-based simulation", *Industrial Management and Data Systems*, Vol. 116 No. 2, pp. 240-259, doi: [10.1108/IMDS-05-2015-0220](https://doi.org/10.1108/IMDS-05-2015-0220).
- Sahu, A.K., Katayyan, A., Khandey, U., Jangde, P., Sahu, A.K. and Sahu, N.K. (2023), "Adaptation of blockchain technology in SCM for steering managerial strategies: investigative study under Indian context", *Journal of International Logistics and Trade*, Vol. 21 No. 1, pp. 18-40, doi: [10.1108/JILT-06-2022-0020](https://doi.org/10.1108/JILT-06-2022-0020).
- Sahu, A.K., Kottala, S.Y., Narang, H.K. and Rajput, M.S. (2024), "Intertwining green SCM- and agile SCM-based decision-making framework for sustainability using GIVTFNs", *Journal of Global Operations and Strategic Sourcing*, Vol. 17 No. 2, pp. 300-333, doi: [10.1108/JGOSS-06-2022-0060](https://doi.org/10.1108/JGOSS-06-2022-0060).
- Sayed Saif-Eddine, A., El-Beheiry, M.M. and El-Kharbotly, A.K. (2019), "An improved genetic algorithm for optimizing total supply chain cost in inventory location routing problem", *Ain Shams Engineering Journal*, Vol. 10 No. 1, pp. 63-76, doi: [10.1016/j.asej.2018.09.002](https://doi.org/10.1016/j.asej.2018.09.002).
- Shah, H.M., Gardas, B.B., Narwane, V.S. and Mehta, H.S. (2023), "The contemporary state of big data analytics and artificial intelligence towards intelligent supply chain risk management: a comprehensive review", *Kybernetes*, Vol. 52 No. 5, pp. 1643-1697, doi: [10.1108/K-05-2021-0423](https://doi.org/10.1108/K-05-2021-0423).
- Sharma, R., Shishodia, A., Gunasekaran, A., Min, H. and Munim, Z.H. (2022), "The role of artificial intelligence in supply chain management: mapping the territory", *International Journal of Production Research*, Vol. 60 No. 24, pp. 7527-7550, doi: [10.1080/00207543.2022.2029611](https://doi.org/10.1080/00207543.2022.2029611).
- Soori, M., Arezoo, B. and Dastres, R. (2023), "Artificial neural networks in supply chain management: a review", *Journal of Economy and Technology*, Vol. 1, pp. 179-196, doi: [10.1016/j.ject.2023.11.002](https://doi.org/10.1016/j.ject.2023.11.002).
- Sundarakani, B., Manikas, I. and Gunasekaran, A. (2024), "The role of digital transformation in achieving sustainable supply chain management in Industry 4.0: an editorial review perspective", *International Journal of Logistics Research and Applications*, Vol. 27 No. 6, pp. 843-851, doi: [10.1080/13675567.2024.2332123](https://doi.org/10.1080/13675567.2024.2332123).

- Tetteh, F.K., Atiki, G., Kyeremeh, A., Degbe, F.D. and Apanye, P. (2024), "Linking business analytics capability and sustainability performance: the mediating role of circular economy implementation", *Modern Supply Chain Research and Applications*, Vol. 6 No. 3, pp. 226-246, doi: [10.1108/MS CRA-12-2023-0049](https://doi.org/10.1108/MS CRA-12-2023-0049).
- Vo, N.N.Y., He, X., Liu, S. and Xu, G. (2019), "Deep learning for decision making and the optimization of socially responsible investments and portfolio", *Decision Support Systems*, Vol. 124, 113097, doi: [10.1016/j.dss.2019.113097](https://doi.org/10.1016/j.dss.2019.113097).
- Wamba, S.F. and Queiroz, M.M. (2020), "Blockchain in the operations and supply chain management: benefits, challenges, and future research opportunities", *International Journal of Information Management*, Vol. 52, 102064, doi: [10.1016/j.ijinfomgt.2019.102064](https://doi.org/10.1016/j.ijinfomgt.2019.102064).
- Wamba, S.F., Queiroz, M.M., Guthrie, C. and Braganza, A. (2021), "Industry experiences of artificial intelligence (AI): benefits and challenges in operations and supply chain management", *Production Planning and Control*, Vol. 33 No. 16, pp. 1493-1497, doi: [10.1080/09537287.2021.1882695](https://doi.org/10.1080/09537287.2021.1882695).
- Wichmann, P., Brintrup, A., Baker, S., Woodall, P. and McFarlane, D. (2018), "Towards automatically generating supply chain maps from natural language text", *IFAC-PapersOnLine*, Vol. 51 No. 11, pp. 1726-1731, doi: [10.1016/j.ifacol.2018.08.207](https://doi.org/10.1016/j.ifacol.2018.08.207).
- Zamani, E.D., Smyth, C., Gupta, S. and Dennehy, D. (2022), "Artificial intelligence and big data analytics for supply chain resilience: a systematic literature review", *Annals of Operations Research*, Vol. 327 No. 2, pp. 1-28, doi: [10.1007/s10479-022-04983-y](https://doi.org/10.1007/s10479-022-04983-y).
- Zhou, R., Awasthi, A. and Stal-Le Cardinal, J. (2021), "The main trends for multi-tier supply chain in Industry 4.0 based on natural language processing", *Computers and Industrial Engineering*, Vol. 125, 103369, doi: [10.1016/j.cie.2021.103369](https://doi.org/10.1016/j.cie.2021.103369).

Corresponding author

Atul Kumar Sahu can be contacted at: atul85sahu@gmail.com