

Supply chain efficiency and performance measurement in the automotive sector: Content analysis and future research directions

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Abstract

Continuous performance measurement is the primary strategy for achieving business success in the current competitive global environment. The performance measurement scheme is a framework for evaluating the efficacy of the supply chain. The objective of this article is to analyze the existing literature and identify potential future research topics in order to investigate the lack of current performance measurement systems research in the supply chain context. The authors conducted a study on the measurement of supply chain performance and discovered that a variety of measuring systems are employed. The research provides a robust foundation for future research.

Keywords: Efficiency, Environment, Measurement, Performance, Supply Chain Management

1. Introduction

Supply Chain Management is defined by the Logistics Management Council as "the process of planning, implementing, and controlling efficient and cost-effective material flow, in-process inventory, finished products, and associated data from the point of order to the point of consumption in order to meet customer demands." Directly or indirectly, all parties involved in satisfying client demand are engaged in a supply chain. Manufacturers, distributors, transporters, warehouses, distributors, and even consumers comprise the supply chain (Sharma et al., 2023). Over the past few years, researchers and professionals have devoted significant attention to Supply Chain Management (SCM).

Efficiency and performance measurement in supply chain has been an important area of research (Sinha, 2020) and the automotive sector has not been left behind. Studies indicate how technology and automation mainstream improve the efficiencies of the automotive supply chain processes by increasing the turnover ratios, order delivery, and cost-saving measures (Rupnawar et al., 2024). Moreover, the disruptive nature of events that happened in the recent past, including the COVID-19 pandemic, calls for the implementation of creative performance

measurement systems, including the lean performance measurement systems, that would help to cope with disruptions and enhance the effectiveness of the supply chain (Sangwa *et al.*, 2023). In addition, the revelation of the performance measurement frameworks that actually relate with the automotive spare parts supply chain has been highlighted as a major contribution, enabling efficiency of performance evaluation by various markers on the different dimensions that exist in the automotive aftermarket (Achetoui *et al.*, 2022). Altogether, these research works underline the use of information technology, developing and integrating the efficient performance measurement system and enhancing the existing and new supply chain processes in the competitive automotive industry.

A range of business organisations have widely practised SCM; therefore, a wide review is essential to capture the performance of business organisations (Lehyani *et al.*, 2021). Supply Chain Performance corresponds to supply chain activities that address the needs of the client (Reddy *et al.*, 2019). The effective SCM in the automobile industry is achieved through the processes of collaborative forecasting, lean manufacturing, and supplier management under which the performance measurement methods are the SPC, FMEA, and Six Sigma. Another method involved in the management of the supply chain is costing and it is correlated with the efficiency of the supply chain. They show whether SC resources are optimally consumed; whether it is in the economic, human, technological or physical context.

This study examines the performance and effectiveness of supply chains in the past twenty years, specifically in the automobile industry. It evaluates the methods, strategies, and performance assessment used in this field. The objective of this research is to conduct a thorough examination of the effectiveness of the supply chain and the measurement of performance in the automobile industry. There are a total of 48 scholarly publications from respected journals and international conferences that have been included. The primary objective of this study is to be more precise and focused:

- Classify SCPEM research articles according to their strategy and methods
- Identify future research agenda.

2. Research Finding

Table 1 demonstrates the distribution of study articles in different publications and international conferences

Table 1. Number of articles from different journals

Journal Name	No. of Articles
International Journal of Production Economics	5
IEEE	4
International Conference	4
Supply Chain Management: An International Journal	3
International Journal of Supply Chain Management	2
International Journal of Services and Operations Management	1
Industrial Engineering and Engineering Management	1
International Journal of Advance Engineering and Research Development	1
International Journal of Logistics Systems and Management	1
Journal of Logistics Management	1
Benchmarking: An International Journal	1
Expert Systems with Applications	1
Global Networks	1
International Journal of Advanced Manufacturing Technology	1
International Journal of Managing Value and Supply Chains	1

International Journal of Operations & Production Management	1
International Journal of Production Research	1
International Journal Intercultural Information Management	1
Journal of Applied Business Research	1
Journal of Intelligent Manufacturing	1
Journal of Manufacturing Technology Management	1
Journal of Theoretical and Applied Information Technology	1
Journal of Transport and Supply Chain Management	1
Measuring Business Excellence	1
Procedia - Social and Behavioural Sciences	1
Procedia CIRP	1
Proceedings - International Symposium on Parallel Architectures, Algorithms and Programming	1
Proceedings from the 21st IMP Conference	1
Production Planning & Control	1
Resources, Conservation and Recycling	1
Scientific Research and Essay	1
Supply Chain Forum: An International Journal	1
Sustainability	1
Sustainable Design and Manufacturing	1
Total Quality Management & Business Excellence	1

The research contribution, finding and problem-solving approach of all reviewed paper are as shown in Table 2.

Table 2. Research contribution

Author's Work and Finding	Approach
Deepika et al. (2011) use the ANP to highlight the comparative significance of various competitiveness determinants and discover that client demand is the most significant competitive component.	Analytic Network Process (ANP)
The paper Joshi et al. (2013) examine the competitiveness determinants of the Indian automotive component (IAC) manufacturing sector, in particular the performance indices of its supply chain (SC) using ANP.	Analytic Network Process (ANP)
Ghose (n.d) offer an inner economic benchmarking methodology to decrease the uneven performance of Hero Honda, Bajaj Auto and TVS Motor supply chains and conclude that Compared to Bajaj Auto and Hero Honda, the length of SC in TVS engines is greater.	ANOVA: Two-way classification.
Goedhals-Gerber (2016) propose a model to assist South African companies enhance their competitiveness and assess South African industries ' level of effectiveness. The author assesses the effectiveness of individual companies and the general supply chain level.	Composite Supply Chain Efficiency Model (CSCEM)

Azfar et al. (2014) classify precedents of current SC paradigm and SC performance measurement methods and propose a suggested conceptual structure for current SC paradigms.	Conceptual framework
Beamon (1999) presents an assessment of SC models' performance measures and suggests a structure for the choice of performance measurement technologies for SC production.	Conceptual framework
Gunasekaran et al. (2004) developed a framework for understanding the significance of SCM performance measurement and metrics based on the outcomes of empirical research of chosen British companies.	Conceptual framework
Moser et al. (2011) develop a benchmarking framework to analyze its supply network setup and illustrate its applications in the Indian automotive industry.	Conceptual framework
Estampe et al. (2013) propose a structure of distinct SC performance assessment methods to enable managers to select the model that provides the assessment they need.	Conceptual framework
Gholampour and Abdul Rahim (2015) explore variables for predicting supply chain operational efficiency through IRANKHODRO Company (IKCO) survey and case study research.	Confirmatory factor analyses (CFA)
Marodin et al. (2017) explain lean production practices focusing on operational performance in the Brazilian automotive SC and provide a better understanding of lean practices and their impact on performance measurement.	Correlation and factor analysis
Danese and Romano (2011) analyze the effect of client inclusion on effectiveness and the moderating role of provider integration and shows that provider integration positively affects client integration and efficiency relationships.	Correlation and regression analysis
Dev et al. (2014) analyze of the overall supply chain effectiveness in the light of average fill rate results.	DEA
Chang and Chiu (2010) measure the relative efficiency of the supply chain by dividing it into a central control system (CCS) and a decentralized control system (DCS) case and conclude that the efficiency of a centralized control system is greater than that of a decentralized control system.	DEA
Yousefi and Hadi-Vencheh (2010) propose an integrated model to examine Iran's automotive industry's enhancement areas and show that security and then cost are the most significant automotive selection criteria.	DEA, AHP
Mathivathanan et al. (2018) give a more explicit knowledge of the interrelated factors between Sustainable Supply Chain Management SSCM practices with a specific look at the automotive industry.	DEMATEL Tool
Borgström (2005) describe and evaluate activity-based efficiency and efficiency as discovered in supply chains.	Duality/dualism perspective
Couzin et al. (2001) analyze of the inbound supply chain of the automotive industry employing supply and transport prisms that link suppliers of initial machinery and vehicle manufacturers.	Field survey

Saibaba and Rao (2012) reviewed information on Hero Honda and Bajaj Auto Dealers' supply chain procedures by creating order frequency, order lead times and process time metrics to deliver client orders and compared them to the effectiveness aspect.	Filed Survey
Bhattacharya et al. (2014) examines trends such as visibility and innovation, cooperation and supply networks and changing management positions in Indian automotive supply chain efficiency.	Framework
Saleheen and Habib (2023) proposed integrated supply chain performance measurement model (ISCPM).	Framework
Negri et al. (2023) built a performance measurement framework to simultaneously include sustainability and resilience indicators.	Framework
Chan and Qi (2003) propose an innovative SCM performance measurement technique and described a fuzzy set theory structure to tackle the actual scenario in the process of judgement and assessment.	Framework and Fuzzy theory
Dai and Li (2015) propose an optimization model of the automotive supply chain network with risks at fuzzy prices.	Fuzzy
Humphrey (2003) examines globalization in the context of altering relationships between assembler and supplier in the automotive industry.	Global value chain approach
Mohamed and Youssef (2017) develop a comprehensive analysis of the risk variables in the automotive supply chain.	Hierarchy of criticality
Katiyar and Barua (2014) identify main obstacles to applying the Supply Chain Performance Measurement System (SCPMS) to enhance supply chain efficiency and effectiveness.	Interpretive Structural Modeling (ISM)
Pettersson and Segerstedt (2011) investigate SC performance measurement and SC costs in 30 Swedish companies in various industries and demonstrate that businesses define excellence more by focusing on performance than on price.	Interview and case study
Gopal and Thakkar (2016) analyze of critical success factors (CSFs) in the practical application of Indian automotive supply chain practices.	ISM
Amrina and Yusof (2012) analyze the interrelationships between essential performance indices of sustainable automotive production assessment.	ISM
Woolliscroft et al. (2013) identify the significance of solid knowledge sharing to recognize and integrate essential vendors in the Slovak automotive sector from a knowledge management view.	Knowledge management
Khadem et al. (2017) developed a Linear Deterministic Program (LP) model for the poultry industry supply chain in Oman.	LINGO optimization software.
Severino and Godinho Filho (2017) describe how the scheme of paired cell overlapping card loops (POLCA) helps coordinate the manufacturing flow in SC.	POLCA system
Behrouzi and Wong (2011) identify key lean SC performance elements and their actions focusing on tiny and medium-sized organizations in the automotive industry in Iran.	Principal component analysis

Nguyen and Nguyen (2017) examines the effect of SC inclusion on the competitive advantage and shows that supply chain integration positively affects supply chain responsiveness and competitive advantage.	Reliability and validity tests and multiple regressions
Charan (2012) applied a situation-actor-process (SAP)-learning-action-performance (LAP) model for an automotive manufacturer's case study in Gurgaon, India and exhibits the impact of different respondents on the organization's supply chain performance.	SAP LAP model
Ivanov and Jaff (2017) propose research to reduce the impact on the inner supply chain of production lead time.	Survey
Thomé et al. (2014) analyze of the impacts of flexible SC capabilities in the Brazilian automotive industry SCs at different levels.	Survey
Thun and Hoenig (2011) identify the risk of the supply chain by examining main SC risk drivers and evaluating their likelihood of occurrence. The author shows that businesses with a high level of execution demonstrate better SC efficiency.	Survey and cluster analysis
Sad and Patel (2006) identify performance measurement sets for the performance of the supply chain in a developing country.	Survey and factor analysis
El Farouk Imane and Fouad (2017) present a structure for the synchronous flow of raw material between the car manufacturer and the initial machinery maker at the Renault plant.	Survey case study
Sahay et al. (2006) analyze of studies on the present state of SCM practices in Indian organizations and recognition of key fields that need to be focused on enhancing competitiveness.	Survey questionnaire
Othman et al. (2016) examine the effect of supply chain inclusion, just-in-time (JIT) buying and JIT production on automotive providers' performance in Malaysia and highlights their important advantages.	Survey questionnaire and regression analysis
Pourhejazy and Kwon (2016) present a systematic review of more than 380 papers in sophisticated O.R. released between 2005 and 2016. Techniques used to optimize the supply chain network.	Systematic review
Shang et al. (2004) propose a strategy that integrates simulation, Taguchi methods and surface response methodology to study relationships between distinct variables that help identify the 'best' SC working circumstances.	Taguchi and RSM
Kamariah Kamaruddin and Mohamed Udin (2009) recognize the significance of SC technology adoption variables and investigate their impact on automotive providers to embrace supply chain technology (SCT) within the organisation. The outcome of their study demonstrates that there is a favourable connection between organizational structure and organizational size and the implementation of SCT.	The survey questionnaire and ANOVA
Akafia et al. (2017) measured the new service policy's impact on Toyota Ghana Company Limited's SC performance (TGCL) and determined a significant impact on the supply chain's service production.	The survey questionnaire and paired sample t-test

The distribution of various research methodologies across the studies is illustrated in the chart in Figure 1. It emphasizes the most frequently employed methodologies, including surveys, conceptual frameworks, and a variety of statistical methods.

As for the research methodologies in supply chain management (SCM), they vary in accordance with the objectives of a study, field of interest or industry analysis as well as the specific area of SCM under consideration. Table 3 describes the comparison of main methodologies in terms of the content analysis

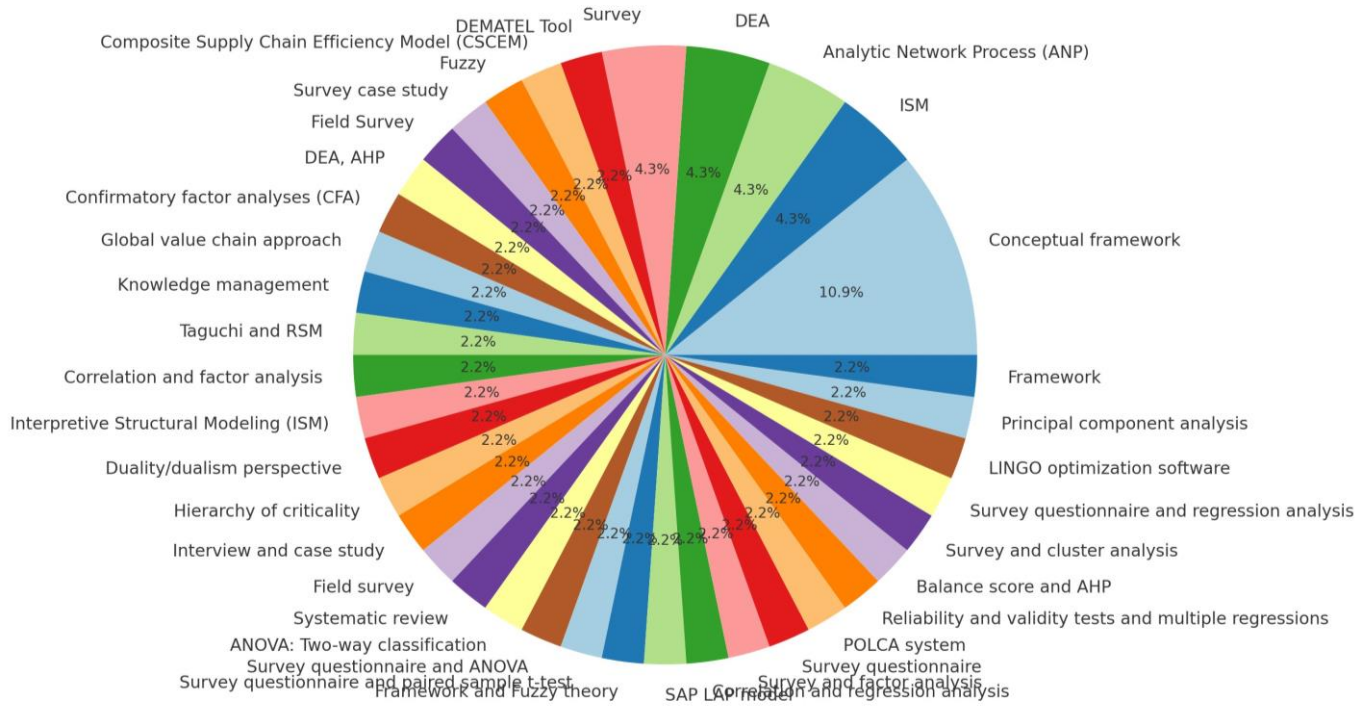


Figure 1. Distribution of different research methodologies

Table 3. Comparison of key methodologies

Methodology	Strengths	Weaknesses	Typical Applications
Conceptual Framework	Provides a structured approach to understanding complex SCM phenomena.	May lack empirical validation; often theoretical.	Used in early-stage research to propose new models or frameworks.
Empirical Analysis (Surveys/Field Studies)	Offers real-world insights and data-driven conclusions.	Time-consuming and may suffer from response bias.	Applied in studies seeking to measure actual SCM practices and outcomes.
Statistical Methods (ANOVA, Regression, etc.)	Enables precise analysis of relationships between variables.	Requires a solid understanding of statistics; may oversimplify complex phenomena.	Used in research aiming to establish causal relationships or test hypotheses.

Case Studies	Provides in-depth insights and context-specific findings.	Limited generalizability due to focus on specific cases.	Ideal for exploring new or complex issues within a particular organization.
Fuzzy Theory and Optimization Models	Deals effectively with uncertainty and complex decision-making.	Complex to implement and interpret; may require specialized software.	Used in advanced SCM optimization, particularly in uncertain environments.
Systematic Reviews	Summarizes and synthesizes existing research, identifying trends and gaps.	Dependent on the quality and scope of the reviewed literature.	Useful for researchers needing an overview of the field or identifying research gaps.
Taguchi and RSM (Response Surface Methodology)	Optimizes processes by systematically varying parameters.	May be limited to processes that can be modeled mathematically.	Often used in manufacturing to optimize production processes.
Interpretive Structural Modeling (ISM)	Helps in understanding and visualizing relationships among variables.	Can be subjective, depending on expert judgments.	Used for exploring complex interdependencies, often in risk management.
Analytic Network Process (ANP)	Captures complex decision-making involving multiple criteria.	Requires expert input, which can be subjective.	Applied in strategic decision-making, such as selecting SCM strategies.
Balance Scorecard and AHP	Balances multiple perspectives (financial, customer, process, learning) in SCM evaluation.	Can be complex to implement, particularly in aligning different perspectives.	Used in performance measurement, especially in evaluating overall SCM effectiveness.

Main difficulties in managing a supply chain are listed in the Table 4 accompanied by the event-based strategies to mitigate these problems.

Table 4. Key challenges and solutions

Key Challenges	Solutions
Integration and Coordination	ERP Systems, CPFR, Supply Chain Visibility Tools
Risk Management	SCRM Frameworks, Diversification of Suppliers, Business Continuity Planning
Technology Adoption	Pilot Programs, Training and Change Management, Cloud-Based SCM Solutions
Sustainability and Ethical Practices	GSCM, Sustainable Sourcing, Circular Economy Models
Demand Forecasting and Inventory Management	Predictive Analytics and AI, JIT Inventory, Inventory Optimization Software
Globalization and Complexity	Supply Chain Network Design, Localization Strategy, Advanced Analytics
Cost Management	Lean Manufacturing, Strategic Sourcing, Cost-to-Serve Analysis
Regulatory Compliance	Compliance Management Systems, Regulatory Risk Assessment, Engagement with Regulatory Bodies

Integration and Coordination is one of the most important supply chain management issues because the real essence of the concept is to ensure all the links in the chain work in perfect harmony. The solutions are such as the adoption of ERP, these systems aids in integrating various functions and department in an organization, and the utilization of collaborative tools such as CPFR (Collaborative Planning, Forecasting, and Replenishment).

Supply Chain Risk Management entails the forecast of risk that may occur along the supply chain and the formulation of measures to overcome these risks. The table proposes to address risks with the help of the consecutive structured Supply Chain Risk Management (SCRM).

Technology Adoption is crucial for competitive advantage, However it is a problem area because of the costs and change resistance. Some of the solutions are to launch pilot projects to implement innovations as alphabets and numbers to experience reduced scales of implementation, and participate in training and change management to make transitions smoother, and lastly, the adoption of cloud-based solutions for SCM, implying flexibility works in a cost-free model.

Sustainability and Ethical Practices are evolving now among the organizations because of the pressure created by the statutory and regulatory authorities and the pressure groups to adhere to more environmentally responsible policies and ethical business practices. GSCM and sustainable sourcing are strategic solutions while adopting the principles of circular economy that minimize recycling and wastage ought to be deemed as solutions.

The two have already been identified as key to inventory management and in ensuring that every customer gets exactly what he or she needs. Applications of prediction and AI are suggested to enhance the ability to predict efficiently, while JIT decreases holding costs. Inventory optimization software can open yet another front in increasing efficiency, that is through the adaptation of inventory with the demand.

Globalization increases the head scratching as they complicate the supply chains that may traverse through different borders with different regulations. Minimizing the number of echelons in the supply chain network, following a localization strategy instead of a globalization one, using modeling to simulate ideas, are ways of managing this complexity.

Cost management enable organizations to strike a balance between achieving a low cost and the quality and satisfaction of the customer. Lean production practices center on eradicating waste, while the strategic sourcing covers every total cost of acquisition and ownership; cost-to-serve analysis enables the understanding of real cost of serving particular markets, and hence, directs more intelligent decisions.

Overcoming another challenge involved in Regulatory Compliance is difficult because the laws and standards vary from one region to another. Automated compliance management systems are used to assist organizations in operating compliant with international standards. Scalability and its relation with regulation means that frequent regulation risk evaluations as well as interaction with the key regulatory authorities allow firms to adapt to the shifting legal framework as little as possible.

A mind map of content analysis is illustrated in Figure 2. The content is a thorough examination of supply chain management practices, with a particular focus on the automotive industry's performance measurement, technology adoption, and integration. Conceptual frameworks, empirical research, and sophisticated statistical methods are employed in a balanced manner. The results consistently underscore the significance of risk management, benchmarking, and integration in improving supply chain performance. Future research is expected to concentrate on sustainability and advanced technologies. Depending on the research objectives, this analysis can be used as a basis for a more in-depth examination of specific themes or methodologies.



Figure 2. Mind map of content analysis

3. Discussion

The analysis demonstrates a thorough approach to SCM research, with a particular emphasis on the automotive industry and regions such as India. Driven by both empirical validation and theoretical frameworks, the field is transitioning toward sustainability, risk management, and digitalization. There are opportunities to broaden research into other industries and regions, as there is an increasing emphasis on technological innovation and ethical practices. The relevance and impact of SCM research in addressing real-world challenges are maintained by the balance between theoretical and practical focus.

Globalization and recent global disruptions (e.g., COVID-19) have likely resulted in a heightened emphasis on technology adoption and risk management over the past decade.. India is the most frequently examined region, which is consistent with the country's increasing involvement in global supply chains, particularly in the automotive sector. Southeast Asia and Europe are also represented, albeit to a lesser extent. This implies that regional nuances are crucial, particularly in emerging markets, despite the widespread study of global SCM practices. The methodologies that are employed most frequently are conceptual frameworks and empirical analyses (e.g., surveys, field studies). These are frequently associated with the identification of challenges and the proposing of solutions in SCM, particularly in the areas of performance measurement, risk management, and technology adoption.

Supply chain efficiency, cost reduction, lead times, and customer satisfaction are among the most frequently used key performance indicators (KPIs) in the studies. Evaluation of the efficacy of SCM strategies and technologies is contingent upon these key performance indicators (KPIs). The significance of these metrics in both academic research and practical applications is underscored by their frequent use. The influence of AI, blockchain, and IoT on supply chain efficacy, transparency, and risk management is the subject of research that concentrates on technology adoption. These technologies are recognized as critical enablers of contemporary SCM, providing solutions to conventional obstacles such as visibility and coordination.

The comparison between traditional and modern SCM approaches reveals a shift towards digitalization, automation, and sustainability. While traditional methods focused on cost and efficiency, modern approaches emphasize resilience, agility, and environmental impact.

Different approaches used by researcher except framework, correlation regression, factor analysis, ANOVA, and Taguchi are follows.

1. Survey based approach

Almost 26% of the reviewed articles have applied survey based research. The survey is a flexible research approach used to explore a wide range of topics (Kumar et al., 2023b). Researchers often use the questionnaire as an instrument for information collection in this strategy. This method is a very traditional method of conducting research and is most helpful for non-experimental studies aimed at describing reality.

2. Data envelopment analysis

Analysis of data envelopment (DEA) is a non-parametric method in the studies of activities. It is used empirically to evaluate decision-making units (or DMUs) productive effectiveness. DEA is a helpful instrument for evaluating multi-input and multi-output organizations, taking qualitative and quantitative measures into account.

3. Interpretive Structural Modeling

An interactive learning method is Interpretive Structural Modeling (ISM). It is an evolving methodology that is very helpful to understand a complicated situation (Kumar et al., 2023a). Creating a visual map generates logical connections between distinct components; it is structural relationships between system components.

4. Analytic Hierarchy Process

It is an efficient instrument to deal with complicated decision-making and can help decision-makers set priorities and make the best decision. AHP helps capture subjective as well as objective elements of a decision.

5. Analytic Network Process

It is a generalization of the Analytic Hierarchy Process (AHP), taking into account the hierarchy elements' dependence. Many decision issues can not be hierarchically organized because they involve the interaction and reliance of higher-level components in a lower-level element hierarchy. ANP is therefore depicted not by a hierarchy, but by a network.

6. Decision-Making Trial and Evaluation Laboratory

This technique was used to show the interrelationships between criteria and identify aspects / criteria that play a key role in the scheme to reflect their efficiency (Sharma et al., 2022).

7. Simulation

Simulation is the imitation of a real-world process or system activity over time. First of all, the act of simulating something involves the development of a model; this model reflects the main features, behaviours and functions of the physical or abstract system or process chosen. The model is the system itself, while the simulation represents the system's operation over time

4. Conclusion

This research analyzed the growth of SCPEM methods and automotive methods by analyzing papers published in last two decades reputable journals and international conferences. The study shows that an important quantity of job has been done in the SCPEM region over the previous two centuries. The constituents of SC performance assessment schemes were collected and it was found that according to the SC approach, a SCPEM could consist of different methods, criteria and metrics.

Based on the comprehensive analysis of the content, here are some suggested future research directions:

- Assess the effects of new technologies such as Artificial Intelligence, Distributed Ledgers Technology/Blockchain, Internet of Things (IoT) and Big data analytics in the respond, visibility and volatility of the supply chain.
- Engage researchers in order to develop frameworks and models that can be used to explain the risk and resilience of global supply chains, particularly during disruptions such as pandemics, the current state of geopolitical unrest and climate change.
- Examine more about the occurrence of supply chain in selected and appropriate humanitarian and disaster relief organizations, the speed, efficiency and coordination demonstrated under supply chain emergencies.
- Investigate the outcomes of numerous collaboration and integration approaches in the SC links between suppliers, manufacturers, and customers, especially in digitally linked supply chains.

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