Chapter 1

Multi-Criteria Decision-Making Methods Application in Supply Chain Management: A Systematic Literature Review

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Additional information is available at the end of the chapter

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Abstract

Over the last decade, a large number of research papers, certified courses, professional development programs and scientific conferences have addressed supply chain management (SCM), thereby attesting to its significance and importance. SCM is a multi-criteria decision-making (MCDM) problem because throughout its process, different criteria related to each supply chain (SC) activity and their associated sub-criteria must be considered. Often, these criteria are conflicting in nature. For their part, MCDM methods have also attracted significant attention among researchers and practitioners in the field of SCM. The aim of this chapter is to conduct a systematic literature review of published articles in the application of MCDM methods in SCM decisions at the strategic, tactical and operational levels. This chapter considers major SC activities such as supplier selection, manufacturing, warehousing and logistics. A total of 140 published articles (from 2005 to 2017) were studied and categorized, and gaps in the literature were identified. This chapter is useful for academic researchers, decision makers and experts to whom it will provide a better understanding of the application of MCDM methods in SCM, at various levels of the decision-making process, and establish guidelines for selecting an appropriate MCDM method for managing SC activities.

Keywords: SCM, MCDM, strategic, tactical and operational decision-making, fuzzy, AHP/ANP, TOPSIS, systematic literature review

1. Introduction

Supply chain management (SCM) is crucial in today's competitive environment and is steadily gaining serious research attention. Companies are facing challenges in discovering ways to fulfill ever-rising customer expectations and remain competitive in the market while keeping costs manageable. To that end, they must carry out investigations to isolate inefficiencies in their supply chain (SC) processes. If a company is buying raw materials for use in manufacturing a product, which it then sells to customers that mean the organization has an SC, which it must then manage. According to [1], SCM is:

"A set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements."

SCM involves managing a series of activities relating to the planning, coordination and control of the movement of materials, parts and products from suppliers; the management of inventories of procured parts and of issues relating to production; an appropriate and cost-effective storage of products, and finally, transportation to the customer.

Another approach defines SCM in terms of different decision-making (DM) levels, namely, strategic, tactical and operational, and indicates that these DM levels of all scales optimize SC performance. On the other hand, traditional SC can be defined as a network which consists of suppliers, manufacturing facilities, distribution centers from which we procure raw materials, converted into finished good and deliver it to end user [2].

Certain differences exist between SCM and traditional logistics. Traditional logistics consists of actions that usually occur inside single organization boundaries, while SCM essentially defines a network of different companies working in coordination, with their main goal being to deliver finished products to customers. In addition, traditional logistics emphasizes SC functions, including purchasing, distribution and inventory management. SCM includes all the components of traditional logistics, but also tags on actions such as new product development, finance, marketing and customer service [3]. In this chapter, we consider following SC functions as mentioned in **Figure 1**.

1.1. Decision-making in SCM

An organization's strategic, tactical and operational decision-making plays a vital role in ensuring that its SC is operating efficiently, allowing it to achieve the highest levels of customer satisfaction at an optimum cost. Decision-making at each level should focus on gaining a competitive edge

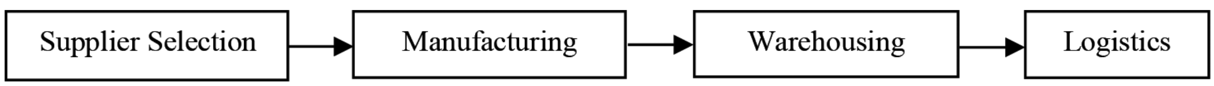

Figure 1. Considered SC functions.

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and increasing market share. At each level, the nature of decision-making as well as and the related activities are different. There are three levels of decision-making which are (1) strategic-level decisions that have a long-lasting effect on the firm such as decisions related to warehouse location, capacity of warehouse and distribution centers, (2) tactical-level decisions that include decisions for the coming year such as decisions related to production, inventory level, absorption of uncertainty in production plan, transportation, and so on and (3) operational decisions that include decisions which are usually day-to-day such as loading/unloading, daily production plan, and so on.

1.2. MCDM methods and SCM

MCDM is a technique that combines alternative's performance across numerous, contradicting, qualitative and/or quantitative criteria and results in a solution requiring a consensus [4, 5]. Knowledge garnered from many fields, including behavioral decision theory, computer technology, economics, information systems and mathematics is used. Since the 1960s, many MCDM techniques and approaches have been developed, proposed and implemented successfully in many application areas [6, 7]. The objective of MCDM is not to suggest the best decision, but to aid decision makers in selecting shortlisted alternatives or a single alternative that fulfils their requirements and is in line with their preferences [8–10] mentioned that at early stages, knowledge of MCDM methods and an appropriate understanding of the perspectives of DM themselves (players who are involved in decision process) are essential for efficient and effective DM.

There are several MCDM methods available such as the analytical hierarchal process (AHP), the analytical network process (ANP), TOPSIS, data envelopment analysis (DEA) and fuzzy decision-making. MCDM has been one of the fastest growing problem areas in many disciplines [11]. Over the past decade, many researchers have applied these methods in the field of industrial engineering, particularly in SCM, in making decisions. All the methods are equally capable of making decisions under uncertainty, and each one has its own advantages.

SCM is an MCDM problem because in the entire SC cycle, we must consider different criteria related to each sub-criterion of the SC cycle. In order to manage the entire SC, we have to identify the relationship of each criterion, which in turn impacts the performance of the SC. Based on the indicators identified, we then make decisions. This shows that decision-making is critical in managing the SC cycle, and that SCM is an MCDM problem. Supply chain management decisions are made under the conflicting criteria of maximizing profit and customer responsiveness while minimizing SC risk. Multiple criteria decision-making in supply chain management provides a comprehensive overview of multi-criteria optimization models and methods that can be used in SC decision-making [12].

1.3. Objective of the study

The objective of this study is to provide a systematic literature review on the application of MCDM methods in the decision process related to the considered SC functions (supplier selection, manufacturing, warehousing and logistics). The literature will be also categorized in terms of decision-making level (strategic, tactical and operational) and sector/application area during the decision process. This study is an attempt to answer the following research questions:

a. What is the (%) distribution of MCDM methods applications in terms of different SC decision levels (strategic, tactical and operational) and in the SC functions considered?

b. What is the (%) distribution of MCDM methods applications in terms of area of application?

c. What are the top MCDM methods applied at each SC functions considered and at different SC decision levels (strategic, tactical and operational).

2. Research methodology

In order to systematically carry out our literature review and use content analysis in the process, we adopt a methodology composed of four steps, based on the practical guidelines provided by Seuring & Gold [13] and Seuring et al. [14]. The process model consists of following steps as mentioned in **Figure 2**.

Step 1: The scope of the literature review in this chapter is limited to academic reviewed journals, conference papers and graduate dissertations because of their academic relevance, accessibility and ease of search. We did not include unpublished works, non-reviewed papers, working papers and book chapters. Inclusion of such papers is suggested as a future extension of our work. Papers using only MCDM methods and its integration with MODM methods were also included. However, papers focused solely on applied MODM methods were not included because it is beyond the scope and objective of this study. We searched within titles and abstracts in the Emerald, Elsevier, Taylor & Francis, Springer and Inderscience databases. Keywords that we used are “SCM and MCDM”; “Strategic and SCM”; “Tactical and SCM”; “Operational and SCM”; “MCDM and Supplier selection”; “MCDM and manufacturing”; “MCDM and warehousing”; “MCDM and logistics”; “DM and Supplier Selection”; “DM and Manufacturing”; “DM and Warehousing”; “DM and Logistics”; and so on. We used non-method-specific and method-specific MCDM keywords, DM keywords and SCM keywords. The material selection process led to samples of 140 papers published in more than 80 journals (the complete reference list is presented in a separate reference list).

Step 2: As recommended by [13], descriptive analysis must contain the distribution of selected reviewed articles in terms of time period, papers per country and across journals. Therefore, **Figure 3** shows the annual distribution of selected articles across the period of study (2005–2017), **Figure 4** shows the top five journals and **Figure 5** shows distribution of articles published per country.

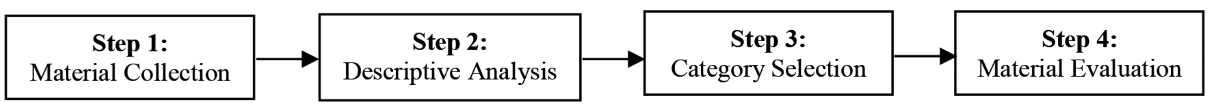

Figure 2. Literature review methodology.

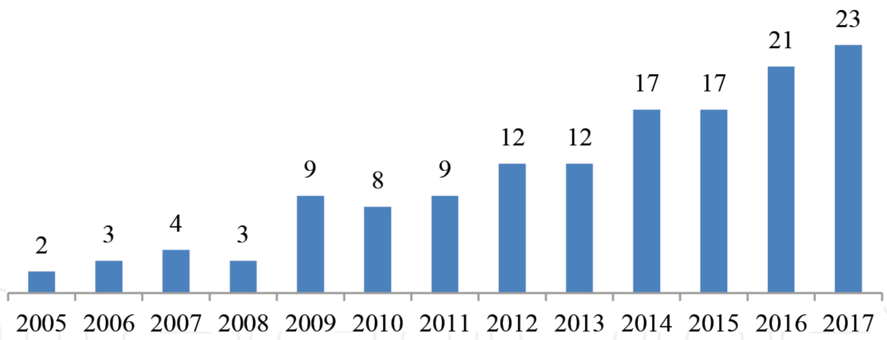

Figure 3. Annual distribution of selected articles across the period of study (2005–2017).

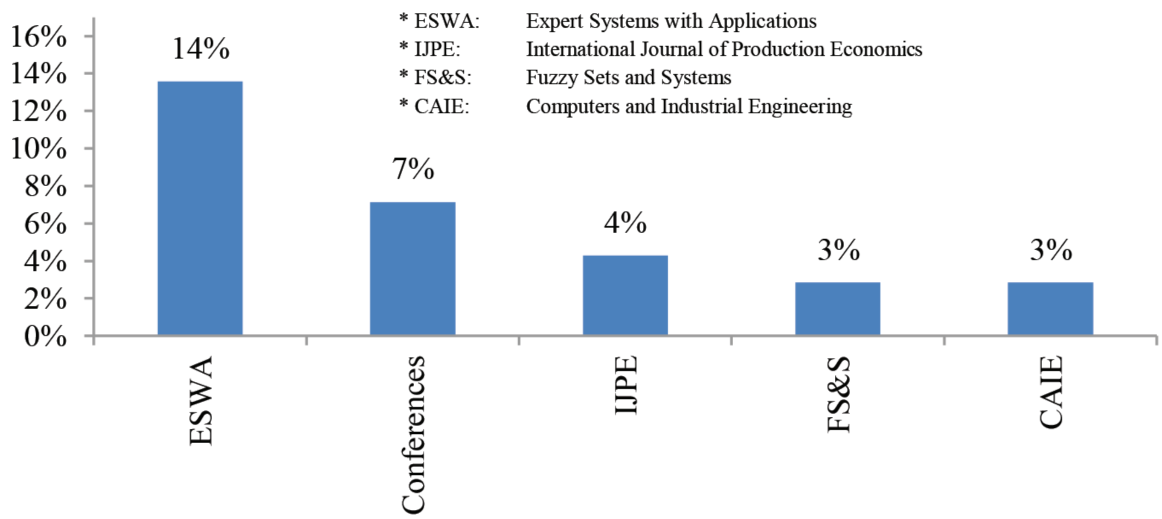

Figure 4. Top four journals of selected reviewed articles.

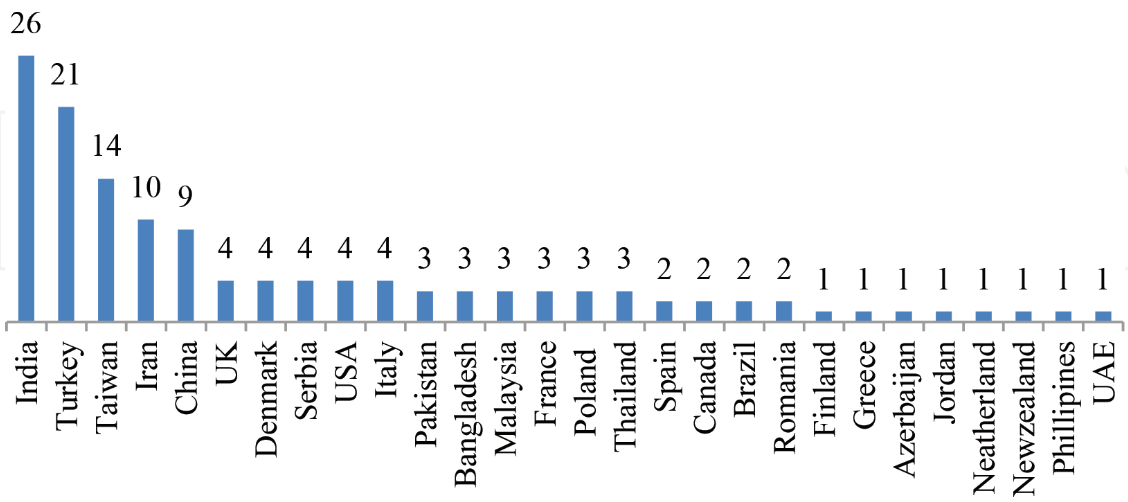

Figure 5. Distribution of articles published per country.

Step 3: Category selection is the most important and essential step of any literature review paper. Category selection developed in this chapter is in line with the objectives set in Section 1.3 and will be able to answer research questions set in the last section. Therefore, in this chapter, we categorized papers in terms of decision-making level, SC functions considered, MCDM methods used and application area. In this step, each author assigned each paper to the specific category. Distribution of papers according to the DM level is aligned with the DM level explained in the abovementioned section, while the SC functions distribution is in line with the standard SC functions definition. Other dimensions, such as the application area and methods applied, were identified by reading the abstract, and in some cases, the conclusion of the article.

Step 4: Once the category selection has been developed, categories' definitions have been clarified, and the papers were reviewed and categorized accordingly. We developed decision rules, and all authors were agreed on developed rules. All papers were read and categorized by individual reviewer, and all authors came up with the same distribution of articles. Only 11% of the papers had differences which were resolved by discussion. We paid attention to ensure the quality, reliability and validity of the review.

In the discussion given in the following section, we first show qualitative results and then proceed with a quantitative analysis.

3. Qualitative results

In this section, a systematic review of the literature on the application of MCDM methods will be discussed. We divided the literature review into the functions of SCM considered; decision-making level, sectors/application area, and country. Category selection of any literature review paper is critical to select paper and accept or reject them based on inclusion or exclusion principles.

3.1. Supplier selection

Many authors have used different MCDM methods to select suppliers strategically for different purposes and in different applications such as the best supplier selection based on sustainability principles, to integrate information on supplier behavior in a fuzzy environment, to solve the supplier evaluation problem in companies with bulk production costs associated with raw materials, and so on. At the tactical level, supplier selection involves the administration of procurement activities such as multi-product supplier selection problem, factors affecting the supplier selection process, and so on. At the operational level, supplier selection usually involves one-time procurement due to unavoidable factors. At this level of decision-making, a small quantity of a product is usually procured from a supplier to run the production line. **Table 1** shows the categorization of papers in terms of decision-making level, MCDM methods used, application area/sector and country in supplier selection.

3.2. Manufacturing

Strategically, decision-making associated with manufacturing involves capacity constraints, manufacturing process selection, and make-or-buy decisions, development of a structural model

Papers	MCDM methods used	Sector/application area	DM level			Country
			Strategic	Tactical	Operation	
[15]	FAHP	SME	●			Thailand
[16]	FTOPSIS	General	●			Tunisia
[17]	FTOPSIS	Fertilizer industry	●			India
[18]	AHP and VIKOR	Automotive	●			India
[19]	Fuzzy- Grey Theory	Steel industry	●			China
[20]	Fuzzy Systems	General	●			China
[21]	FAHP	Railway operations		●		Brazil
[22]	FAHP	Manufacturing industry	●			Italy
[23]	AHP-QFD	Automotive	●			Pakistan
[24]	AHP -TOPSIS	General		●		India
[25]	AHP	Automotive			●	India
[26]	AHP	Automotive		●		Pakistan
[27]	AHP-TOPSIS	IT industry			●	Morocco
[28]	Electre III	Packaging industry				Romania
[29]	Fuzzy	Agri food industry			●	Iran
[30]	Fuzzy Systems	Gear manufacturing	●			China
[31]	Fuzzy-QFD	Hospital	●			Turkey
[32]	Fuzzy multi-objective	General		●		USA
[33]	Fuzzy Axiomatic Design	Plastic material manufacturer	●			Denmark
[34]	FAHP	Airline		●		Netherlands
[35]	FANP	Automotive		●		Malaysia
[36]	FTOPSIS	Energy	●			Turkey
[37]	FTOPSIS	Automotive	●			Iran
[38]	FAHP	Publishing company			●	Iran
[39]	FTOPSIS and MILP	Air filter manufacturing		●		Turkey
[40]	FTOPSIS	Detergent manufacturing		●		Iran
[41]	FAHP	General	●			Turkey
[42]	Fuzzy-MISO	Fiber manufacturing	●			India
[43]	FAHP and Fuzzy Objective LP	Garment manufacturing			●	India
[44]	FAHP	General	●			India
[45]	FAHP	Washing machine manufacturing			●	Turkey
[46]	FTOPSIS and MCGP	Watch manufacturing	●			Taiwan
[47]	TOPSIS	General	●			Italy
[48]	FAHP	Steel	●			Greece

Papers	MCDM methods used	Sector/application area	DM level			Country
			Strategic	Tactical	Operation	
[49]	FAHP	Manufacturer of medical Consumables	●			Taiwan
[50]	FTOPSIS	Automotive	●			Turkey
[51]	TOPSIS-Grey Theory	General	●			Italy
[52]	Fuzzy System	General	●			China
[53]	AHP - MILP	General	●			China
[54]	Fuzzy-TOPSSIS	General		●		Taiwan
[52]	Fuzzy Objective Linear Programming	General	●			India

Table 1. Use of MCDM methods in supplier selection at different DM levels.

to identify the cause-and-effect relationships between different criteria in manufacturing, and so on. At the tactical level, the decisions considered are related to the production rate, demand forecast errors, utilization of manufacturing facilities and administrative constraints. MCDM methods are widely applied at the tactical level of manufacturing decision-making. At the operational level, the decisions considered are related to the rejection rate during manufacturing, cycle time and machine breakdown.

Table 2 shows the categorization of papers in terms of decision-making level, MCDM methods used, application area/sector and country in manufacturing.

3.3. Warehousing

Due to high client expectations, warehousing decisions are vital for organizations. At the strategic level, the decisions the authors and researchers in the literature considered were warehouse location selection, space utilization and urban distribution center location. Warehousing decisions have a long-term impact on the overall SC, and as a result, trade-offs must be made between conflicting alternatives. At the tactical level, the decisions considered were warehouse layout design, cost per order and response rate. Many authors applied MCDM methods for tactical warehousing decisions. At the operational level, the decisions considered were damages, reconciliation error and order fulfillment rate. Only a few applications of MCDM methods can be found in the literature on warehousing decisions at the operational level. **Table 3** shows the categorization of papers in terms of decision-making level, MCDM methods used, application area/sector and country in warehousing.

3.4. Logistics

Logistics plays an important role in overall SC performance. At the strategic level, the decisions researchers considered were logistics provider selection, service reliability and freight cost.

Papers	MCDM methods used	Sector/application area	DM level			Country
			Strategic	Tactical	Operation	
[56]	DEMATEL- ANP & Grey Relational Analysis- TOPSIS	General	●			China
[57]	SAW- WASPAS- TOPSIS	PVC windows manufacturing	●			Poland
[58]	AHP-DEMATEL	Paint shop	●			India
[59]	FAHP- PROMETHEE	Mining equipment manufacturer		●		India
[60]	AHP-TOPSIS and SWOT	Mining industry	●			Iran
[61]	AHP	Heat devices manufacturing	●			Poland
[62]	AHP-WASPAS	Laser cutting		●		Serbia
[63]	TOPSIS	Face milling			●	India
[64]	TOPSIS	Micro EDM			●	India
[65]	Fuzzy System	General	●			Denmark
[66]	Fuzzy-DEMATEL	General		●		Iran
[67]	Probabilistic Fuzzy-ANP	General	●			Philippines
[68]	Fuzzy-VIKOR	Hard disk manufacturing	●			Malaysia
[69]	Fuzzy System	General	●			UK
[70]	Fuzzy-ANP and TOPSSIS	General		●		India
[71]	DEMATEL-ANP	Rubber, tire and tube manufacturing		●		Denmark
[72]	AHP	Mining industry		●		India
[73]	Fuzzy Decision Tree	Aircraft	●			UK
[74]	Fuzzy-DEMATEL	General	●			Taiwan
[75]	Type 2 Fuzzy hybrid experts system	Steel manufacturing		●		Iran
[76]	Fuzzy Based Genetic Algorithm	General	●			Bangladesh
[77]	Fuzzy System	General		●		Finland
[78]	Fuzzy-TOPSIS	Cement manufacturing	●			India
[79]	Fuzzy DEMATEL	Automotive	●			Iran
[80]	ANP - VIKOR	Textile		●		USA
[81]	ANP-DEMATEL	Manufacturer of medical consumables		●		Taiwan
[82]	DEMATEL	General		●		Taiwan
[83]	Fuzzy - MP	General	●			Turkey
[84]	Fuzzy Sets	General		●		Spain
[85]	Fuzzy System	General		●		UK

Papers	MCDM methods used	Sector/application area	DM level			Country
			Strategic	Tactical	Operation	
[86]	Fuzzy - MP	Automotive			●	Spain
[87]	Fuzzy Linear Programming	Textile industry		●		Malaysia
[88]	Fuzzy linear regression, Fuzzy time series and Fuzzy grey GM	General		●		Turkey
[89]	Fuzzy-AHP	Electronics		●		Taiwan
[90]	Fuzzy integrated model with fuzzy objective function	Home Appliance Company		●		Azerbaijan

Table 2. Use of MCDM methods in manufacturing at different DM levels.

Papers	MCDM methods used	Sector/application area	DM level			Country
			Strategic	Tactical	Operational	
[91]	Fuzzy	Winery’s warehouse	●			Argentina
[92]	AHP	Automotive	●			Others
[93]	AHP	General	●			India
[94]	FAHP and FTOPSIS	General	●			India
[95]	FAHP and FANP	General	●			Turkey
[96]	FAHP	Injection molded parts mfg.	●			Pakistan
[97]	FAHP	Retail industry	●			Serbia
[98]	Fuzzy	General	●			India
[99]	Fuzzy Multi-attribute	General	●			China
[100]	Fuzzy	General	●			Italy
[101]	Electre III	General		●		Poland
[102]	FANP	General	●			Iran
[103]	FTOPSIS - MCGP	Airline		●		Taiwan
[104]	AHP	Logistics service provider		●		Bangladesh
[105]	TOPSIS	Retailing channel	●			Taiwan
[106]	Fuzzy System	Logistics service provider		●		Taiwan
[107]	FTOPSIS	Home appliances	●			Iran
[108]	Fuzzy random multi-objective DM model	Constructions		●		China
[109]	FTOPSIS	Automotive	●			Turkey
[110]	FTOPSIS	General	●			India
[111]	Fuzzy System	Logistic company	●			Canada

Papers	MCDM methods used	Sector/application area	DM level			Country
			Strategic	Tactical	Operational	
[112]	FTOPSIS	Logistic company	●			Canada
[113]	FTOPSIS	General	●			Turkey
[114]	Fuzzy-TOPSSIS	IC Packaging Plant	●			Taiwan
[115]	Fuzzy	General	●			Taiwan
[116]	Fuzzy System	General		●		Jordon
[117]	Fuzzy inference system	General			●	India

Table 3. Use of MCDM methods in warehousing at different DM levels.

Many authors applied MCDM methods and techniques at the strategic level of decision-making in logistics. At the tactical level, decisions considered relate to logistics network design, mode of transport and establishment of logistic centre. At the operational level, the decisions considered were damages, delayed shipment rate, cost per delivery and operational performance (wrong delivery rate, for instance). A few authors applied MCDM techniques at the operational level. **Table 4** shows the categorization of papers in terms of decision-making level, MCDM methods

Papers	MCDM methods used	Sector /application area	DM Level			Country
			Strategic	Tactical	Operational	
[118]	FAHP	Land transport provider	●			Columbia
[119]	DEA	General	●			Valencia
[120]	FAHP	General	●			Thailand
[121]	FQFD-TOPSIS	Agriculture	●			France
[122]	FAHP	General	●			France
[94]	FAHP and FTOPSIS	General	●			India
[123]	FAHP-VIKOR	Electronics industry	●			India
[124]	ANP-BSC	Logistics industry	●			Turkey
[125]	FAHP-TOPSIS	Logistic provider	●			Columbia
[126]	AHP	Logistics industry	●			Turkey
[127]	FDelphi-AHP	General	●			Brazil
[128]	FAHP	Military logistics		●		Taiwan
[129]	FAHP-SWOT	Manufacturer of composite pipes	●			USA
[130]	AHP-DEMATEL	General	●			India
[131]	DEMATEL and FANP	Telecommunication	●			Turkey
[132]	Electre III	General	●			Romania
[133]	Fuzzy			●		Taiwan

Papers	MCDM methods used	Sector /application area	DM Level			Country
			Strategic	Tactical	Operational	
		Semiconductor manufacturing				
[134]	Fuzzy-VIKOR	General	●			New Zealand
[135]	FAHP and FTOPSSIS	Tire manufacturing		●		Turkey
[136]	Fuzzy DEMATEL, Fuzzy ANP and Fuzzy VIKOR	City logistics	●			Serbia
[137]	FAHP	Logistics company	●			Thailand
[138]	FAHP and FTOPSIS	City Logistics	●			Serbia
[139]	TOPSIS-AHP	Telecommunication	●			India
[140]	AHP	Aerospace		●		USA
[141]	QFD - FAHP	Hard disk component manufacturer	●			UK
[142]	FAHP	FMCG	●			Bangladesh
[143]	FAHP	Garment material manufacturing		●		China
[144]	Fuzzy-Delphi	Logistic company	●			Turkey
[145]	FTOPSIS	Logistic company	●			Turkey
[146]	FTOPSIS	Automotive			●	India
[147]	AHP-TOPSIS	Automotive		●		Turkey
[148]	FAHP	Logistic Company			●	Turkey
[149]	FTOPSIS	Logistic Company			●	Turkey
[150]	FAHP	Logistic Company	●			Turkey
[151]	ISM-Fuzzy	Battery manufacturing company		●		Denmark
[152]	ANP	FMCG			●	India

Table 4. Use of MCDM methods in logistics at different DM levels.

used, application area/sector and country in supplier selection, manufacturing, warehousing, and logistics, respectively.

4. Quantitative result analysis

Today, competition is shifting from individual company performance to SC performance, thus making it essential for companies to measure their SC performance effectively and efficiently. To that end, they need to identify appropriate methods for evaluating the measurement of the

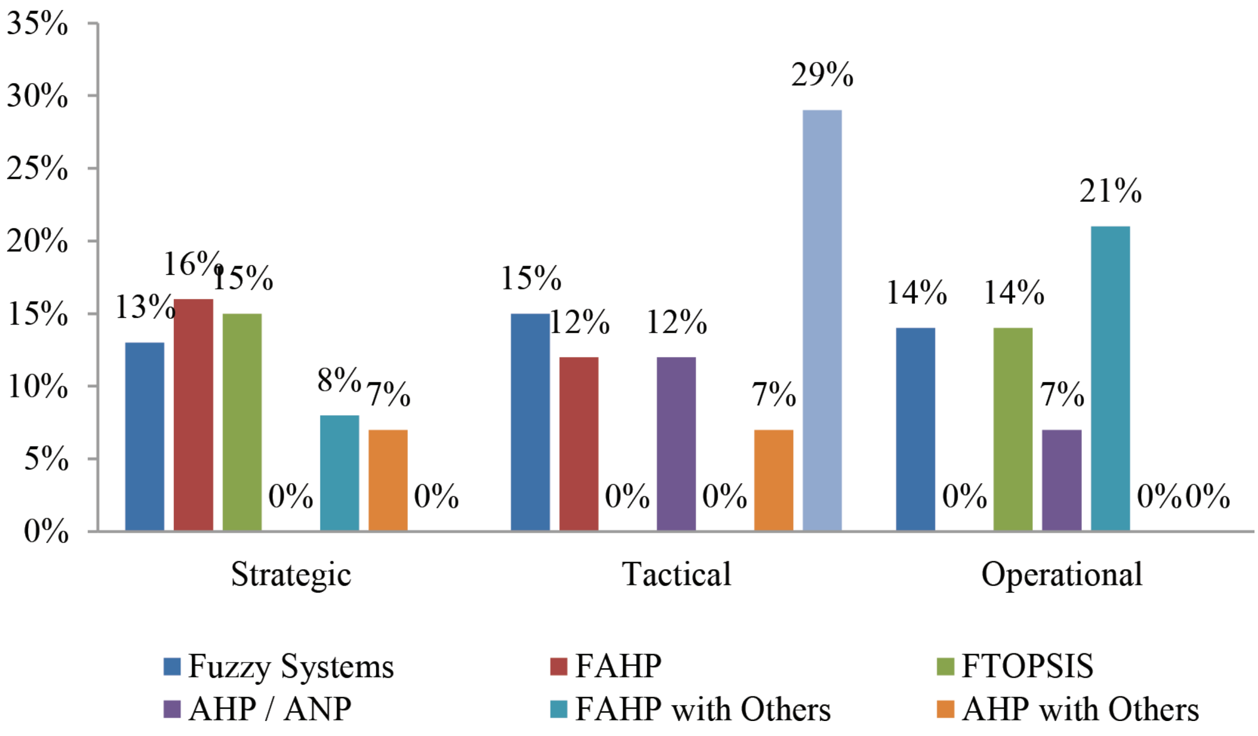

Figure 6. MCDM approach at the strategic, tactical and operational level.

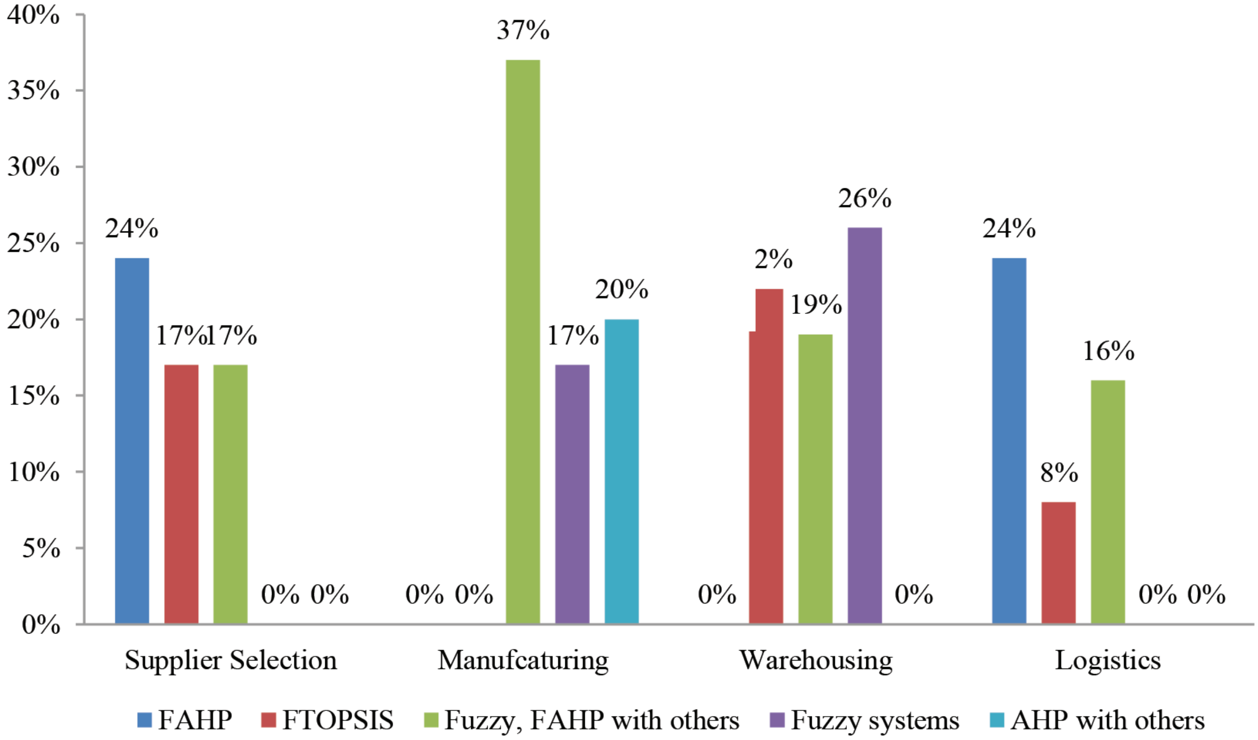

Figure 7. Top three MCDM methods of considered SC functions.

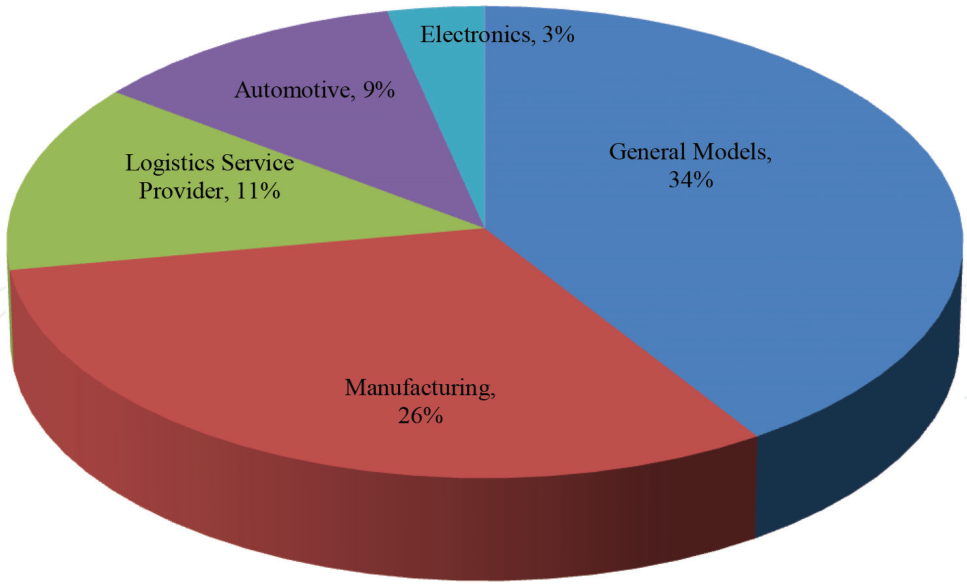

Figure 8. Paper distribution of the application areas for MCDM methods.

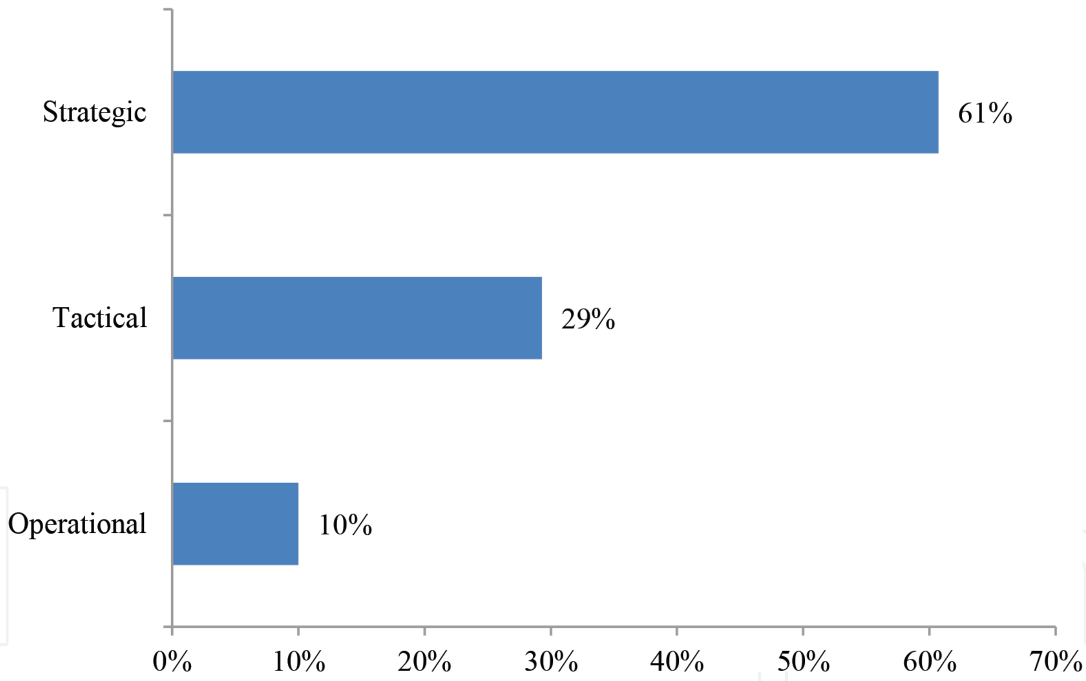

Figure 9. Paper distribution at different levels of DM.

performance of the entire SC cycle. This study will help managers, practitioners and researchers select the most appropriate MCDM method for managing their SC cycle and analyze the results quantitatively in the following aspects.

a. **Figure 6** shows the percentage of papers covering each MCDM methods at different strategic, tactical and operational levels of SC decisions.

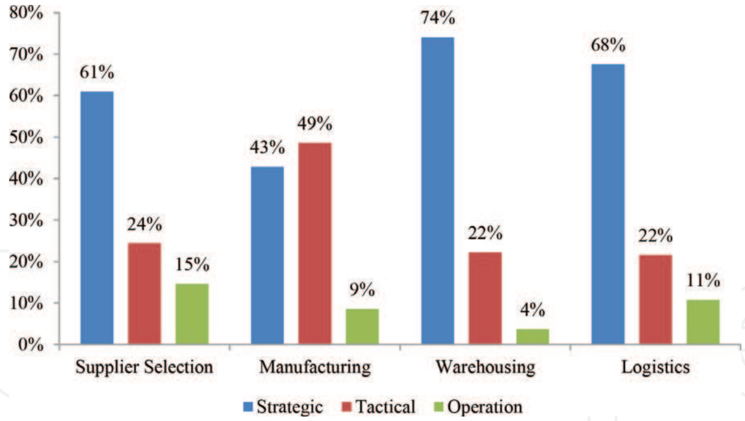

Figure 10. Paper distribution at different levels of DM of considered SC functions.

b. **Figure 7** shows the top three MCDM methods for considered SC functions which are supplier selection, manufacturing, warehousing and logistics.

c. **Figures 8** and **9** show the paper distribution of the application areas for MCDM methods and its distribution at different levels of DM.

d. **Figure 10** shows the paper distribution at different levels of DM in considered SC functions.

After summarizing the methods at the strategic, tactical and operational levels of decision-making, researchers and practitioners can now easily select most widely used MCDM methods in SC decision-making. Further, this research will help managers select a suitable technique from widely used MCDM methods for supplier selection, manufacturing, warehousing and logistics.

This study considered the application of MCDM methods in almost all sectors. After an extensive literature review, we found that many authors, managers and researchers have applied MCDM methods in many sectors and at different DM levels as mentioned in **Figures 8** and **9**, respectively.

Managers and decision makers need to select the best method at each level of decision-making in the entire SC. **Figure 10** shows the use of MCDM methods at each level of decision-making in the entire considered SC cycle. We can infer from the figure that at a strategic level, 74% of papers applied MCDM methods in warehousing decisions; at a tactical level, 49% of papers used MCDM methods in manufacturing; and at an operational level, 15% of papers used MCDM methods in supplier selection.

5. Discussion

The systematic literature review on the application of MCDM methods in supply chain management demonstrates the richness of MCDM to take different DM perspectives in the decision process. At the early stage of application, most of the methods focus on the fragmented SC structure with inefficient processes at the supply, manufacturing, warehousing and logistics levels. The subsequent integration of SC processes motivates the application of MCDM to improve the global decision process (more holistic). However, the integration comes with many challenges. First, more criteria have to be considered in the decision process. Second, the number of decision makers increases.

For long-term decisions (strategic and tactical), the decision process involves many criteria resulting from the information collected through the different SC functions. Also, most often, different decision makers (SC actors) are involved in the decision process. Thus, the use of MCDM methods is more suitable for long- and mid-term decisions (around 90%). However, the application of MCDM for short-term decisions (operational/real time) is limited to only 10%. Indeed, operational decisions are made very rapidly, and only partial information is usually available due to lack of data. Thus, the application of MCDM is not predominant and sometimes more difficult to implement.

For the supplier selection process, a detailed analysis (**Figure 10**) shows that MCDM methods are commonly used for long-term (strategic and tactical) decisions (85%). This result can be explained by the intensification of global commerce due to globalization and ever-greater competition, where supplier selection is critical. Thus, the appropriate supplier selection plays a vital role in organizational success. Conversely, the smallest number of researchers and DMs (15%) used MCDM methods at the operational level because of the fact that supplier selection and evaluation decisions have an impact on product quality, delivery, cost of material and service level. Therefore, decisions such as make-or-buy and the establishment of long-term contracts with suppliers must be aligned with the strategic goals of an organization and cannot merely be taken at the operational level.

Regarding the manufacturing process, long-term (strategic and tactical) decisions are also critical and include the development of technology selection and capacity expansion strategies to overcome shortage, minimize cost and maximize overall production efficiency. Again, the literature review analysis shows that 91% of MCDM methods are applied for long-term (strategic and tactical) decisions. For short-term manufacturing decisions, we are usually in the execution process of production, and there is less flexibility in decision-making. Thus, we notice that only 9% of the studies used MCDM methods for short-term decision-making (operational level).

Long-term warehousing decisions include the location and the design (technology choice and capacity) of the facility, which is one of the drivers of SC management. Moreover, the number of facilities (Warehouses and Distribution Centers) determines the total cost and the response time. For that reason, different criteria are used to make appropriate decisions. A significant amount of MCDM methods are applied in this context (96%). However, only 4% of papers applied MCDM methods at the operational level has been reported in our study.

For logistics activities, **Figure 10** shows that many researchers and decision makers applied MCDM methods for long-term (strategic and tactical) efforts (approximately 90%). An effective and efficient logistics system requires long-term planning by considering future expansions, mergers and globalization. Long-term decisions help organizations reduce transportation cost and increase delivery service. For short-term decisions (operational), decision makers are obliged to take rapid action because of uncertainty caused by the manufacturing or logistics service provider. Therefore, this study shows that 11% of researchers and decision makers applied MCDM methods for short-term DM (operational), which is the highest among all considered SC functions.

6. Limitations and further research directions

This chapter has a number of limitations, detailed as follows:

i. This review is limited to academic reviewed journals and conferences. Therefore, unpublished work, non-reviewed articles, working papers and practitioners' articles can be included in a future extension of this research.

ii. This review spanned 13 years (2005–2017), and we believe it is representative of the literature on the application of MCDM methods in SCM. Although this study is not exhaustive, it is however comprehensive (140 papers) enough to allow a conclusion.

iii. In the allocation of DM levels (strategic, tactical, and operational) in a particular paper, we followed the definition of DM level by David Simchi-Levi, Kaminsky, & Simchi-Levi (2008).

6.1. Future research directions

In SC, there are many criteria that have to be considered while making decisions. These criteria are often conflicting in nature, and MCDM methods and their integration with other methods are able to provide a framework for DMs in solving SCM problems and challenges. Moreover, with more globalization and digitalization, data availability is increasing, and the potential application of MCDM methods in tackling SCM problems under uncertainties becomes inevitable but needs a transformation. Based on this study, the following future research directions are proposed:

i. In future, selected papers of this study can be further analyzed to know uncertain criteria that have been used for internal and external uncertainty in considered SC functions.

ii. Analyzed papers were further examined to know the exact criteria that were considered by DM in considered SC functions.

Notwithstanding the above-mentioned limitations and future research direction, we strongly believe that this study is in a very important area, namely, applications of MCDM methods in SCM, and should fill a gap in the literature.

7. Concluding remarks

This chapter presented a systematic literature review on the application of MCDM methods in considered SC functions, namely, supplier selection, manufacturing, warehousing and logistics. A total of 140 papers covering a time span of 13 years from a well-known database were gathered, analyzed and categorized in terms of a long-term and short-term (strategic, tactical, and operational) DM perspective, MCDM method considered and application area.

This study concludes that the research and application of MCDM methods in SCM have grown significantly in recent years. This study will help managers and decision makers select appropriate MCDM methods at a specific level of DM (strategic, tactical, and operational) and provide guidelines to managers to see which application area uses which MCDM methods. It is evident from the literature that shows that fuzzy sets and its integration with other MCDM methods have effectively and efficiently been applied at every level of the SC decision-making process as well as in the considered SC functions. This is because of the fact that due to digitalization and massive data available in the organization, perspective of SC has been totally changed. Organizations and decision makers need to change their traditional thinking when it comes to how to manage SC. Moreover, due to the availability of real-time data and information, the application of MCDM for short-term decisions will add a great value to the decision process and reduce uncertainty in managing SC. On the basis of this study, we conclude that fuzzy DM is the most appropriate MCDM method to use at different levels of DM and in building general DM models. Therefore, we believe that this systematic literature review answers all research questions that were raised and achieved the main objectives of our research.

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