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# MULTI-CRITERIA DECISION MAKING APPLICATIONS TO INTEGRATE SUSTAINABILITY INITIATIVE INTO THE THIRD PARTY LOGISTICS PROVIDER SELECTION PROCESS: A LITERATURE REVIEW

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**Abstract:** *The purpose of this article is to answer following research questions: (1) Are criteria related to environmental sustainability involved in the process of selecting a third party logistics service provider (3PLP)?, Which of these criteria are most commonly used?, Are they well-defined?, (2) What type of multi-criteria decision making methods (MCDM) method best suits the selection of a 3PLP? Which individual MCDM methods are most commonly used and why? What are their strengths and weaknesses? Is any difference evident in the methods used in the case of sustainable 3PLP selection? A literature review was undertaken to first review most useful selection criteria and MCDM methods for selecting a 3PLP. Secondly, the focus was on analyzing the usefulness of MCDM methods for the logistics industry as well as selection criteria and their classification with a focus on environmental selection criteria and thirdly, to critically evaluate the results. A literature review revealed that fuzzy AHP and fuzzy TOPSIS integrated approaches were most frequently applied. Costs were found to be the most frequently used criteria, followed by information technology (IT), accurate delivery time and accurate quality and quantity. Environmental criteria were less frequently used criteria.*

**Keywords:** *selection of third party logistics service provider, 3PLP, multi-criteria decision making techniques, MCDM, selection criteria, sustainability, a literature review*

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## 1. INTRODUCTION

The competitiveness of any company largely depends on effective supply chain management. In turn, supply chain management depends on various factors such as top management commitment, use of modern technologies, information sharing with supply chain partners, integration with and trust in supply chain partners, higher flexibility, long term vision, focus on core strengths, the efficient management of the logistics chain and recently, increasingly, on sustainability (Lambert and Cooper 2000, Kumar et al. 2015). All the above-mentioned factors are interdependent, which in turn means that poor management or ignoring of any of these factors makes the supply chain less efficient and consequently decreases the competitiveness of companies and their existence on the market.

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Many studies and publications have focused on all of the above mentioned success factors (Thakkar et al. 2008, Singh 2011, Tejjal et al. 2013, Kumar et al. 2014) including sustainability, which has only recently joined the group of success factors. All these publications relate to all key partners of the supply chain, from suppliers, manufacturers, distributors, retailers to the 3PLP, since the efficiency of the supply chain depends on the integration of all partners of the supply chain (Christopher 2016). The exceptions are studies in the field of sustainability. Studies on sustainable initiatives of 3PLP are rare. Moreover, two significant problems were highlighted during a brief literature review. First, unlike other supply chain partners who 'have already put significant emphasis on sustainability, the progress of 3PLP lags behind' (Bajec and Tuljak-Suban 2016) and second, sustainability issues with 3PLPs are rarely included in the selection process. Given the fact that sustainable awareness significantly affects the company's image, higher profits, marketing exposure etc. (Srivastava 2007) and that the sustainable supply chain depends on the eco-efficiency of all partners of the supply chain (Rao and Holt 2005), the above mentioned problems may affect and may already be affecting the competitiveness of the company's supply chain. Taking action in this area is therefore essential but depends on the willingness and goodwill of not only the company (the buyer of logistics services) but also the 3PLP. It therefore seems logical to integrate environmental requirements into the selection process of a logistics service provider, starting with the identification of proper selection criteria and the selection of an appropriate method or combination of methods with which to select a 3PLP.

This article is the logical continuation of the content of the article published by Bajec et al. (2015), the aim of which was to prepare a framework in order to answer the following questions, one related to selection criteria and the other to selection methodologies:

1. 'Are criteria related to environmental sustainability involved in the process of selecting a 3PLP? Which of them are most commonly used? Are they well-defined? Do they cover the entire area of environmental sustainability? Is there any relevant difference between the frequency of the use of environmental sustainability criteria between continents? Is there any difference between the evaluation criteria by continents?' (Bajec et al. 2015).
2. 'What type of MCDM method best suits the selection of a 3PLP? What individual methods are most commonly used and why? What are their strengths and weaknesses? Is any difference evident in the methods used in the case of sustainable 3PLP selection? Is the choice of methods conditioned by the industry wherein the third part logistics activities?' (Bajec et al. 2015).

The aim of this paper is to present the results which answers the above stated research questions. The rest of the article is organized as follows: firstly, a brief overview of MCDM methods and selection criteria are presented; research methodology is described in section two, followed by results presented in section three and critical analyses presented in section four; the article finishes with the conclusion.

## **2. MCDM TECHNIQUES AND SELECTION CRITERIA IN GENERAL**

Problems containing many criteria (tangible, intangible, qualitative, quantitative, subjective, objective, conflicting etc.) and at least two alternatives are treated as MCDM problems. They could be resolved by using MCDM methods which are useful and appropriate for solving various issues, including problems in the logistics sector. Although the field of MCDM techniques is still relatively young, more than 70 different methods exist (Zardari 2014), divided into various groups according to their similar characteristics. A significantly diverse classification of methods was detected during the review, however, the most commonly used classifications are as follows (Aguzzoul 2011, Schramm and Morais 2013, Zardari et al. 2014): (1) Probabilistic methods, (2) Outranking methods, (3) Statistical approaches, (4) Mathematical programming, (5) Artificial Intelligence, (6) Methods based on costs, (7) Linear weighting models, which were also employed in the review.

MCDM problems always contain several alternatives among which decision maker must choose that which is most appropriate. Which alternative is best depends on the criteria identified by the selector (the buyer of a particular service) and must be satisfied by the alternative (the provider of the service). The criteria are the requirements of the selector such as the ability of the provider, performance cost, quality of performance, flexibility etc. Dozens of criteria were found in the literature arranged into very different groups. However, selection criteria are most frequently classified into following groups: (1) operational capability, (2) service level, (3) costs, (4) provider status, (5) environmental capability.

### **3. RESEARCH METHODOLOGY**

A systematic literature review was conducted in three steps: (1) Planning the review, (2) Implementation of the review, (3) Reporting the results (Bajec and Tuljak-Suban 2016). Planning the review included the determination for a review and settling on a research target. Three facts influenced the review on this topic. Firstly, there are many gaps in the existing knowledge regarding the selection process; secondly, the selection of a 3PLP is one of the key risks of outsourcing and third, a large number of MCDM methods which contributes to even greater chaos in the selection process (Bajec and Tuljak-Suban 2016). The implementation of a review started with the determination of the keywords ('decision making methods' AND 'selection of the third party logistics provider OR 'selection of 3PLP'), continued with the determination of a time-frame (studies published from 1999 to 2015) and search boundaries (journal articles as well as conference proceedings, master's theses, books and book chapters were reviewed) and finished with exclusion criteria (studies not written in English and not related to 3PLP). The collection of articles started with reviews of those journals related to multi-criteria decisions and scientific journals in the field of transport, logistics and the supply chain. After that, Google and Web of Science were manually searched, followed by tracing citations from previously found studies. 108 publications in the field of 3PLP selection process were analyzed and critically evaluated. The results of the literature review are presented in the next paragraph.

### **4. REPORTING THE RESULTS**

#### **4.1 Analysis of MCDM techniques for selecting 3PLP**

26 of the most frequently used MCDM methods for 3PLP evaluation and selection were classified into seven groups and were reviewed: (1) Probabilistic methods, (2) Outranking methods, (3) Statistical approaches, (4) Mathematical programming, (5) Artificial Intelligence, (6) Methods based on costs, (7) Linear weighting models. Most frequently used MCDM method for selecting a 3PLP was AHP (applied in 38 studies), followed by TOPSIS (applied in 22 studies), ANP (applied in 16 studies), Linear Programming (applied in 10 studies), VIKOR and DEA (applied in 9 studies) and DELPHI (applied in 7 studies). All the other methods were applied in less than 6 studies.

Two MCDM methods were integrated together in most studies (30 studies), three methods in 22 studies, four methods in 3 studies and five methods in just one study.

Integrated fuzzy MCDM approaches appeared in 38 articles, most frequently in combination with AHP and TOPSIS and less frequently with other MCDM methods. Integrated fuzzy MCDM approaches in combination with Linear Programming appeared in 6 articles, with ANP in 5, with DELPHI in 4 articles, with VIKOR in 3 articles and with ISM, QFD and DEMATEL in 2 articles.

#### **4.2 Analysis of criteria for selecting 3PLP, with an emphasis on environmental criteria**

35 frequently used criteria were detected. Costs were still found to be a key factor when selecting a 3PLP, followed by IT application (operation capability group), accurate delivery time and accurate quality and quantity (service level group). Second place was occupied by IT capability which was quite surprising but does confirm the positive influence of various IT tools on the effectiveness of logistics services. All of the above criteria were applied in more than 50 studies (Bajec and Tuljak-Suban 2016).

The above criteria were followed by many sub-criteria in the area of service level and operational capability. They were detected in less than 50 but more than 20 publications. Value added services, employee satisfaction, performance monitoring and all environmental criteria were used in less than 20 cases. Environmental criteria was found in less than 10 articles. The most frequently used environmental criteria were environmental expenditures, return order process, reverse logistics costs, pollutant released, energy consumption, clean materials and energy use.

### **5. CRITICAL ANALYSIS**

#### **5.1 Evaluation of environmental selection criteria**

A literature review also revealed that environmental selection criteria are well defined and include various environmental logistics activities. Given the variety of criteria as regards the terminology and importance, a sensitive classification of criteria was necessary (Bajec and Tuljak-Suban 2016). The literature in the field of green and reverse logistics, environmental logistics activities etc. was examined and it was found that most authors divide this field into three main groups, namely reverse logistics processes, waste management and green logistics activities. Environmental selection criteria was divided into two groups: (1) ability to offer green logistics services and (2) ability to offer reverse logistics services. The first group includes pollutant released related sub-criteria, energy consumption related sub-criteria, clean material and energy use related sub-criteria and environmental expenditures related sub-criteria. The second group was divided into waste disposal capabilities related sub-criteria and value-added reverse logistics services capabilities (Bajec and Tuljak-Suban 2016).

#### **5.2 Appropriateness of the most commonly used MCDM methods for the logistics industry**

When analyzing the most commonly used methods in the selection of 3PLPs it appeared to be the case that the authors of the studies apply very different methods or combinations of methods without previously verifying whether these methods are indeed the most appropriate for the logistics industry.

The logistics industry is like any other area, unique and having its own characteristics, such as: (1) qualitative and quantitative criteria, (2) subjective criteria, (3) often conflicting criteria, (4) lots of criteria etc. Each of the most frequently used methods was therefore analyzed according to following criteria: the possibility of processing qualitative data, the possibility of processing quantitative data, the ability to eliminate or not eliminate subjectivity, the ease of calculation, which results in fast and simple calculation and availability of software (Table 1). The results of this analyses presented in Table 1 highlight two key issues namely, (1) which method is more appropriate for the characteristics of the logistics industry and which is less useful (2) which methods could be combined together to satisfy all the characteristics of logistics.

Table 1. Strengths and weaknesses of most frequently used MCDM methods

CRITERIA	Outran-king methods		Qualitative	Quantitative	Subjective	Objective	Ease of use	Availability of software
	Electre	Promethee						
Linear weighting models	Fuzzy logic							
	AHP		X	X	X		X	X
	TOPSIS		X	X	X		X	X
	ANP		X	X	X		X	X
	ISM		X		X			
	SMART		X	X	X	X		
	QFD		X	X	X		X	X
	VIKOR		X	X			X	X
	DEMATEL		X	X		X	X	X
	TCO			X		X		
Methods based on costs	ABC			X		X		
	EXPERT SYSTEM		X		X			
	CBR/RBR		X		X			
	ANN		X		X			
	DELPHI		X			X		X
Mathematical programming	Linear prog.			X	X	X		X
	MIP			X		X		
	MOP			X		X		
	DEA			X		X		X
Outran-king methods	Electre		X	X		X		X
	Promethee		X	X		X		X

## 6. CONCLUSION

Logistics plays a very important role in a company's supply chain. 3PLPs, which now increasingly manage an enterprise's logistics chain, are thus entrusted with an important role. The role of the company in selecting a 3PLP is no less important. Knowledge of the selection process of LSPs focused on applying the most suitable method or combination of methods for the logistics industry as well as proper and well-defined selection criteria is therefore essential.

The results of the literature review revealed that the fuzzy integrated approach was the most frequently used, followed by AHP, ANP and TOPSIS (belonging into Linear weighting models group), DEA, VIKOR, DELPHI and DEMATEL. Other methods were rarely used. It was found that not all methods are suitable for the logistics industry and as a result an analysis was done of the

most commonly used methods. At the same time, it was found that fuzzy logic is an effective tool that could solve problems connected with vagueness, but the rules on which it is based must be taken into account consistently and without exception.

As regards the selection criteria, the review of the literature has shown that costs are still a key factor when selecting a LP, closely followed by IT support and various factors related to the quality of service. Criteria connected with environmental protection are located at the bottom of the list. They are, however, quite well-defined and cover the whole area of environmental protection.

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