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Research Article

Determining the Green Supplier Selection Criteria in Textile Enterprises and Selecting the Most Ideal Distribution Model: A Case Study of Giresun

Çağlar Karamaşa, Ph.D.*

Assist. Prof., Department of Business Administration, Faculty of Economics and Administrative Sciences, Anadolu University, Eskişehir, Turkey, ckaramasa@anadolu.edu.tr

Selçuk Korucuk, Ph.D.

Assoc. Prof., Bulancak Kadir Karabaş School of Applied Disciplines, Giresun University, Giresun, Turkey, selcuk.korucuk@giresun.edu.tr

Mustafa Ergün, Ph.D.

Assist. Prof., Bulancak Kadir Karabaş School of Applied Disciplines, Giresun University, Giresun, Turkey, mustafa.ergun@giresun.edu.tr

* Anadolu Üniversitesi, İşletme Fakültesi Yunusemre Kampüsü, Eskişehir, Türkiye

ABSTRACT

Supplier selection is an important process that needs to be emphasized if customer satisfaction and operating efficiency are to be attained. Businesses also need to take into account environmental sustainability as part of the criteria when selecting their suppliers. This is in line with the need for enterprises to prioritize ecological conditions in their supply chain components such as production, distribution, and storage. On top of the supplier selection problem, another component of the chain that has an impact on the performance and efficiency of the enterprise, especially due to the accompanying costs, and which needs to be given much consideration is the distribution. This study aims to determine the significance levels of the factors that need to be taken into account when determining the criteria to be used in the selection of a green supplier and an ideal distribution model for the company. The study the SAW method to determine the significance levels of the factors and the ROV method to obtain the ideal distribution model. The results revealed that the most important factors were "quality", "green elements" and "service" while the least important factors were found to be "delivery" and "technical elements", respectively. The most ideal distribution model was the "Feeding Flight Model".

Keywords: Green Supplier Selection, Distribution Model, MCDM, SAW, ROV

1. Introduction

The purchasing process is one of the basic functions of a business, and the selection the right supplier is one of the most important aspects of this process. This process directly affects the production costs, product quality, and procurement processes of the enterprises. It is not possible for businesses to produce low-cost, high-quality goods without suppliers that can meet the desired demand in an intensely competitive environment (Liu and Zhang, 2011).

The dependence of businesses on suppliers so that they can deliver quality goods and services makes the process of evaluation and selection of suppliers a vital function of the business. In order to maintain a competitive edge, the business should, therefore, adopt a systematic evaluation model for supplier selection when determining potential and suitable partners.

As for the factor of distribution, the transportation and distribution management principles applied in the procurement processes, the types of transportation used, and the efficiency of the transportation method directly affects the entire process. Distribution management is mostly constrained and restricted by distribution planning among the various factors affecting the process. For instance, the choice of a distribution model to be included in the procurement policy is affected by factors such as geographical conditions, distance, and economies of scale. These factors combine to determine the types of transportation to be used and whether a combination of transportation types can be used.

The role of the environment and environmental management is becoming more pronounced in business activities with every passing day as organizational stakeholders, such as governments, customers, employees, and competitors, have increased their commitment to the protection of the environment (Lee et al., 2009). The efforts to reduce the risks of climate change through green supply chain operations means that the supplier selection process should not be conducted based solely on the significance of the criteria, just as in the traditional assessment models but should also look at the potential impact as well as the causal relationships. Companies that choose their suppliers should know which suppliers have characteristic training in carbon management and carbon information management systems (Hsu et al., 2013). When organizations try to develop or select a supplier assessment and selection method, they usually outline their specific requirements. Based on these requirements, the organization should be presented with a range of different selection methods with model flexibility and different applications to choose from (Govindan et al., 2015).

With the prominence of environmental protection and sustainable development in today’s business climate, an organization that desires to extend its product life and its sustainability needs to emphasize environmental and green protection, which has become an integral part of social responsibility. In a dynamic, competitive, and regulatory environment, a good green supplier selection model can help reduce environmental and legal risks and increase a company's competitiveness. Supplier selection is a key function in the organization's acquisitions. The selection of the appropriate supplier based on contradictory qualitative and quantitative criteria makes the assessment process a multi-criteria decision-making (MCDM) problem (Kannan et al., 2015).

The selection of a green supplier is an important milestone in the transition to the design and management of environmentally sustainable supply chains. Most of the modeling in green supplier selection is based on the integration of fuzzy theory with traditional MCDM methods (Banaeian et al., 2018). The problem of green supplier selection is one of the most important issues in green supply chain management, which directly affects the performance of manufacturers. This makes the process of developing and putting to use a new decision-making method for the selection of a green supplier an important aspect task of the organization. Although there are many fuzzy MCDM methods that have been used to solve the green supplier selection problem, most of them don't take into account the decision maker's limited rational behavior (Qin et al., 2017). Environmental factors are rapidly emerging as an important issue for consideration by businesses and management consideration and legal and public pressures are increasing on them to put in place good environmental practices. A significant portion of these pressures are activities that are often described as major sources of pollution. Organizations have tried to respond, for example, by developing products and services that use less packaging, reduce pollution, or reduce energy consumption. Although businesses have been blamed for many environmental issues, there is still very little guidance on how to reduce this risk. A potentially effective way to manage a company's environmental policy is to associate it closely with the activities of the purchasing function. The application of environmental management techniques throughout the supply chain may be an appropriate method to improve the environmental performance of an industry (Humphreys et al., 2003).

The study seeks to address the issues outlined above while also looking at ensuring sustainable production, customer satisfaction, and increasing productivity. The study aims to determine the significance levels of the factors that should be taken into consideration when determining the criteria for the selection of a green supplier for textile enterprises that operate in Giresun and to choose the most ideal distribution model. An integration of SAW and ROV methods, which are multi-criteria decision-making methods used in solving complex and difficult problems, was used in the study.

The remaining parts of the study can be summarized as follows: The literature on green supplier selection has been presented in the second part. Theoretical explanations of the SAW and ROV methods are described in the third part. Later, the method was applied in Giresun, and the findings were presented under the implementation part. Limitations and future suggestions are mentioned in the conclusion part.

2. Literature Review

Govindan et al. (2015) reviewed multi-criteria decision-making approaches for supplier evaluation and selection in the literature from 1997 to 2011. They found the most widely used multi-criteria decision-making approach to be the “Analytical Hierarchy Process” (AHP) and that the most considered criteria for green supplier evaluation and selection was the “environmental management system”.

Lee et al. (2009) proposed a model for selecting factors to evaluate green suppliers and evaluate suppliers' performance. They first applied the Delphi method to select the most important sub-criteria for traditional suppliers and green suppliers. In order to evaluate the green suppliers of an anonymous LCD manufacturer in Taiwan, they developed a hierarchical FEAHP (Fuzzy Extended AHP) model and selected the most suitable supplier. The strength of the proposed model is that the uncertainty of expert opinions is taken into account in the evaluation process and the model is easy to implement.

Hsu et al. (2013) presented a green supply chain management-based conceptual framework and operational model to include carbon management in supplier selection. After setting the criteria for carbon management activities for the proposed framework, the DEMATEL method was applied for an electronic company. The application of the DEMATEL method allowed not only the structure and relationships between the criteria but also the basic criteria affecting the choice of suppliers related to carbon management competencies. According to the results of the analysis, training about carbon management and carbon information management systems was found to be the most important criteria.

Kannan et al. (2015) proposed a model for evaluating green suppliers, their performance, and the selection criteria. A fuzzy AD (Axiomatic Design) model based on hierarchy was created to evaluate the green suppliers of a Singaporean company producing plastic raw materials. The methodology was successful in selecting the most suitable supplier. The strength of the proposed model is that, despite the uncertainty of the opinions of experts in the evaluation process, the model is easy to implement.

Banaeian et al. (2018) compared the performance of three popular MCDM methods, including Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), VlseKriterijuska Optimizacija I Komoromisno Resenje (VIKOR), and Grey relational analysis (GRA) when integrated with fuzzy clusters to address problems related to decision uncertainties. The comparison showed that the three fuzzy MCDM methods achieved the same supplier ranking results. Fuzzy GRA had a better time complexity than the other two methods and produced results with fewer steps and processes. They also found that these results were independent of the type of normalization, distance, and aggregation functions used. Another observation was that a consistent sequence of alternatives of all methods is produced when changes in supplier alternatives occur.

Qin et al. (2017) developed a new weighting method based on fuzzy logic. In order to demonstrate the method, they selected a green supplier for a company and performed a sensitivity analysis with the help of granular information technology.

Humphreys et al. (2003) presented the framework for environmental criteria that a company can consider in the supplier selection process. The defined criteria were divided into two main groups: quantitative environmental criteria and qualitative environmental criteria. Criteria for the supplier selection process of a decision support system that integrates this environment and it is a kind of guide for purchasing managers to select suppliers from an environmental perspective.

Dobos and Vörösmarty, (2014), developed a supplier selection method based on a composite indicators model similar to data envelopment analysis. The basic composite indicators model was extended with data envelopment analysis (DEA) efficiency measures to include variable type indicators in the model. This extension made it possible to consider not only the scoring-type composite indicators but also the efficiency measures used in the classical DEA method. These two types of indicators enable decision-making in a two-stage decision-making process. In the first stage, the decision-making units are sorted by composite indicators, and if the suppliers cannot be ordered explicitly, the decision is made on the basis of DEA-like efficiency criteria. In this decision process, the supplier selection problem was solved and common weights were determined for the next application.

Hashemi et al. (2015) presented a case study in the automotive industry to demonstrate the effectiveness of the proposed approach to green supplier assessment and selection problems. They used Analytic Network Process (ANP) to calculate criterion weights. Their study contributed to both decision theory and practice by addressing the limitations of existing models and applying a comprehensive green supplier selection model in a case study of the automotive industry.

Korucuk (2018) examined the effect of green logistics practices on the competitiveness of hospital enterprises and hospital performance in 31 different hospitals (private hospitals, state hospitals, and university hospitals). According to the results obtained; Green procurement, green packaging, and green reverse logistics activities had a positive effect on competitiveness. However, green logistics practices were determined not to have any positive effect on competitiveness and hospital performance when it comes to green production and material management, green transportation, and green storage activities.

Kuo et al. (2010), combined Artificial Neural Networks (ANN) and ANP with DEA to create a green supplier selection system. By using the Delphi method, the final green supplier selection is identified under six dimensions, including “Quality”, “Cost”, “Delivery”, “Service”, “Environment”, and “Corporate Social Responsibility. In each dimension, an ANN is used to combine criteria. The model evaluation results of the sample company showed that the use of ANN and ANP may exceed the limits of DEA. Besides, setting upper and lower limits to limit weights may represent the preferences of decision-makers. This can further strengthen the discrimination power of combining DEA and ANP.

Watrobski and Salabun (2016) proposed the use of multi-criteria decision analysis (MCDA) methodology to develop a dynamic approach for the evaluation and selection of dynamic suppliers. They chose the fuzzy TOPSIS method that enables the collection of numerical and linguistic data from various inputs. In their study intended at selecting a supplier for a cable harness manufacturer, they ranked 25 vendors (for 12 periods), giving the company a diversified pool of suppliers.

Yazdani et al. (2017) developed an integrated approach to evaluate supplier performance and to select the best supplier while simultaneously considering the traditional and green supplier selection criteria. They evaluated and ranked ten alternative green suppliers for a well-known Iranian dairy company using the integrated approach of DEMATEL, QFD model, COPRAS, and MOORA methods.

The most used criteria in supplier selection were environmental management system, pollution control, resource consumption, green image, green innovation, eco-design, green talents, environmental performance, and green products. (Tuzkaya et al., 2009; Lee et al., 2009; Hashemi et al., 2015; Kannan et al., 2015; Qin et al., 2017; Korucuk & Memiş, 2019 Watrobski & Salabun, 2016; Govindan et al., 2015; Korucuk, 2018; Lee et al., 2009).

Based on the literature review conducted, it is clear that more should be done with regards to the determination of the significance levels of the criteria used in the selection of green suppliers. Similarly, the review has also revealed the lack of sufficient studies on the selection of the most ideal distribution model, and this study is intended to contribute to the literature in this regard.

3. Methodology

This study has made use of SAW and ROV methods, which are Multi-Criteria Decision Making (MCDM) methods, in determining the significance levels of the criteria used in the selection of a green supplier for the textile enterprises with institutional characteristics in Giresun and selecting the most ideal distribution model.

The methodology followed differs from statistical analysis techniques in that it evaluates both objective and non-objective factors. Analyzes are carried out following expert opinions and can be shaped depending on whether the opinion of only a single expert will be used or a group of experts (Korucuk, 2021).

In this section, we explain the SAW and ROV methods as used in the determination of the significance levels of the criteria followed in the selection of green suppliers and choosing the most ideal distribution model.

3.1. SAW Method

According to the SAW method developed by Churchman and Ackoff (1954), first, a matrix normalization is performed using the equations given below followed by the sequencing of the alternatives. The values of the alternatives are ranked from big to small and the first alternative is considered to be the highest performing alternative (Savitha and Chandrasekar, 2011).

The steps of the SAW method are given below (Janic and Reggiani, 2003; Yeh, 2003):

Step 1: Normalizing the Decision Matrix

In the first step of the SAW Method, the decision matrix consisting of *m* alternatives and *n* evaluation criteria is normalized using the above equation (10).

$$r_{ij}=\begin{cases}\frac{Xij}{\text{maxxij}} & i=1,\dots,m; \quad j=1,\dots.,n\\ \frac{minxij}{Xij} & i=1,\dots,m; \quad j=1,\dots,n\end{cases} \tag{1}$$

Step 2: Calculation of Preference Values of Alternatives

By multiplying the weight of each criterion with the previously calculated values, the total preference value of each alternative is calculated.

$$S_j=\sum_{j=1}^{m} Wjrij \quad , \text{i=,...,m,} \tag{2}$$

3.2. ROV Method

ROV method is a technique of value range developed by Yakowitz et al. (1993) that grades alternatives according to the total score and measures their performance. This method is easily applicable and consists of three steps: creating the decision matrix, normalizing it, and finding utility functions. The method is said to apply to many multi-criteria decision-making problems and gives quick results since it does not entail complex processes and takes a short time to implement. However, the method has only been used in a small number of studies in the literature (Ulutaş, 2018).

The steps of the ROV method are as follows (Hajkowicz and Higgins, 2008; Ulutaş and Karaköy, 2019):

Step 1: A decision matrix is created.

$$X=[Xij]\begin{bmatrix} z_{11} & z_{12} & z_{1n} \\ z_{21} & z_{22} & z_{2n} \\ \vdots & \vdots & \vdots \\ z_{m1} & z_{m2} & z_{mn} \end{bmatrix} \quad (3)$$

Step 2: Normalization matrix is created using Eqs. (4) and (5).

$$xij = \frac{Xij - Xj^{min}}{Xj^{max} - Xj^{min}} \quad (4)$$

$$xij = \frac{Xj^{max} - Xij}{Xj^{max} - Xj^{min}} \quad (5)$$

Step 3: The best and worst utility functions are calculated for each alternative via Eqs. (6) and (7).

$$Maximize: ui^{+} = \sum_{j=1}^{n} uij\ wj \quad (6)$$

$$Minimize: ui^{-} = \sum_{j=1}^{n} uij\ wj \quad (7)$$

The wj shown in Eqs. (6) and (7) have been obtained using SAW. The weights should meet the following two conditions. If $ui^{-} > ui^{+}$ then the i alternative can be said to be better than the ith alternative regardless of the total score. If this does not happen, the middle point is calculated using the formula below and sorted accordingly.

$$ui = \frac{Ui^{+} + Ui^{-}}{2}, \quad (8)$$

According to the decision model, the factors related to the selection of green suppliers and choosing the most ideal distribution cost model were determined using literature review and expert opinions.

4. Case study

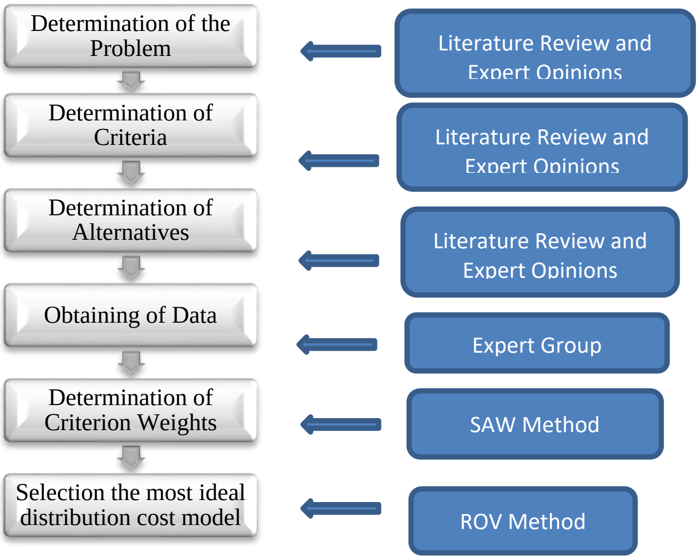

Figure 1. Application Steps of the Study

The processes were performed in the order outlined in Figure 1. According to the decision model, the factors related to the selection of green suppliers and choosing the most ideal distribution cost model were determined by using literature review and expert opinions.

4.1. Weighting the criteria

The weighting of the factors considered in the green supplier selection was done using the SAW method. After the literature review, a survey done with managers, academicians, and the representatives of the Chamber of Commerce and Industry was done to determine the criteria. The research benefited from the studies by Genovese et al. (2010), Nielsen et al. (2014), and Denizhan et al. (2017) and the opinions of the expert group.

Main Criteria	Mark
Technical Elements	C1
Quality	C2
Delivery	C3
Green Elements	C4
Cost	C5
Service	C6

Table 2. Decision Criteria

The study followed a two-stage multi-criteria decision model in order to rank the criteria that affect the selection of green supplier companies and to select the most ideal distribution model. The evaluation steps of SAW-ROV outlined in Figure 1 were followed. Based on these steps, first, the criteria were determined based on expert opinions and literature review. The criteria determined are not of equal importance hence they need to be weighted. The weighting is done using the SAW method are weighted. The weighted criteria are then used in the selection of the most ideal distribution model using the ROV method. The following The table above shows the criteria used in the study as determined through the review of literature and expert opinions drawn from the Chamber of Industry and Commerce and enterprises. A questionnaire was submitted to the managers of Textile Enterprise (20), academicians (2), and the Chamber of Commerce and Industry (3). A total of 25 experts were reached. The tables of opinions are given in the Appendix section. The weights of the criteria determined by the pairwise comparison matrix formed according to the SAW significance scale were found and given in Table 3.

Criteria	Total	Ranking
C1	0,160	5
C2	0,181	1
C3	0,146	6
C4	0,179	2
C5	0,164	4
C6	0,170	3

Table 3. Weight Values for Criteria

According to Table 3, Quality (C2) is found as the most important main criterion for the selection of green suppliers. Other important main criteria were Green Elements (C4), Service (C6), and Cost (C5) respectively. The delivery (C3) criterion for green supplier selection was found to be the least important.

4.2. Ranking alternatives

This section outlines how the ROV method was used to rank the alternatives. Using the weights of the criteria obtained by the SAW method, the most ideal distribution model was selected using the ROV method. The calculations are presented in the Appendices. Firstly, the distribution cost models obtained from literature review (Zylstra, 2006, Goetschalckx, 2008 and Görçün, 2013) and expert opinions are given in Table 4.

Alternatives	Mark
Coordinate Distribution Model	A1
Direct Distribution Model	A2
Shuttle Flight Model	A3
Feeding Flight Model	A4
Linear Flight Distribution Model	A5

Table 4. Distribution Cost Models

To rank the alternatives, the decision matrix was created and then normalized. The weights determined by the SAW method were then used and the results obtained are given in Table 5.

Alternatives	Ui^{+}	Ui^{-}	Ui	Ranking
A_1	0,445	0,109	0,277	2
A_2	0,330	0,164	0,247	3
A_3	0,354	0,109	0,231	4
A_4	0,570	0	0,285	1
A_5	0,339	0,055	0,197	5

Table 5. SAW and ROV Ratings and Ranking

According to Table 5, "A4", in other words, Feeding Flight Model was found to be the best alternative in textile enterprises in the ranking of the most ideal distribution model. The overall ranking of the distribution cost model in textile enterprises is A4> A1> A2> A3> A5.

5. Conclusion

In recent years, the increase in environmental problems, inadequate waste storage areas, and general inexperience have increased the interest in the green supply chain. The negative impact of businesses on the environment has triggered civil society organizations into action and, through global collaborations, a process development period has begun aimed at reducing environmental damage through audit mechanisms. One of the results of this process is green supply chain management, which is considered an environmentalist approach (Coşkun and Bozyiğit, 2019, 628).

The green supply chain phenomenon has started to take root in organizational activities with an ever-increasing role due to motivating factors such as the social responsibility attitude in all segments. Green practices often help to improve environmental performance, minimize waste, reduce costs, improve quality and efficiency, and create synergies with both internal and external customers.

In the process of determining the criteria for the selection of a green supplier, the level of significance of the factors to be considered was determined using SAW, which is a Multi-Criteria Decision Making method. The results of the study reveal that "Quality", "Green Elements" and "Service" are the most important main factors for the selection of green suppliers. The other relatively important main factor was "Cost". The least significant main factors were "Delivery" and "Technical Elements", respectively.

Distribution policies are one of the key concepts in understanding the development occurring in the globalization process. Especially in the current environment, distribution management-related processes present an opportunity for supply chains and businesses to get ahead of the competition. An effective distribution management process also enables the supply chains to widen their international reach and helps the businesses develop or improve their orientation to international markets. The cost element that accompanies the distribution factor makes the process of distribution model selection an important process for the enterprise.

According to the results of the ROV method, the Feeding flight model (A4) was found to be the most ideal distribution cost model in textile enterprises. The overall ranking of the distribution cost model alternatives is A4> A1> A2> A3> A5.

This research will contribute to a better understanding and improvement of the selection of green suppliers in our country and selecting the most ideal distribution model. The results obtained in this study are expected to give insight to practitioners in the textile sector as well as other sectors. Future studies could look at different sectors as well as use different methodologies to evaluate the factors considered in green supplier selection and use methodologies that enable comparison to domestic and international research.

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Appendix

Appendix 1. Decision Matrix and Maxmin r-Rj Values for SAW Method

	Criteria Types	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**Maxmin r-R_j**
C_1	Max.	2,20	3,11	2,44	3,10	1,93	3,91	3,91
C_2	Max.	2,75	3,01	3,21	3,04	2,91	2,75	3,21
C_3	Max.	3,10	2,87	1,75	2,77	3,07	2,44	3,10
C_4	Mix.	4,55	1,99	1,88	2,60	3,15	3,17	1,88
C_5	Max.	3,27	3,33	2,85	3,89	3,56	4,20	4,20
C_6	Max.	4,46	3,73	1,55	4,01	4,17	3,10	4,46

Appendix 2. Normalization Matrix for SAW Method

	Criteria Types	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
C_1	Max.	0,563	0,795	0,624	0,793	0,494	1
C_2	Max.	0,857	0,928	1	0,947	0,907	0,857
C_3	Max.	1	0,926	0,565	0,894	0,990	0,787
C_4	Mix.	0,413	0,945	1	0,723	0,570	0,593
C_5	Max.	0,779	0,793	0,679	0,926	0,848	1
C_6	Max.	1	0,836	0,348	0,899	0,935	0,695

Appendix 3. ROV Method Decision Matrix

Alternatives	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
A_1	3	4	3	4	3	3
A_2	4	3	3	2	2	4
A_3	3	4	3	3	3	3
A_4	4	3	4	4	5	3
A_5	4	3	3	4	4	2

Appendix 4. Matrix Normalized by ROV Method

Alternatives	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
A_1	0	1	0	1	0,667	0,500
A_2	1	0	0	0	1	1
A_3	0	1	0	0,500	0,667	0,500
A_4	1	0	1	1	0	0,500
A_5	1	0	0	1	0,333	0