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ORIGINAL PAPER

EVALUATION OF SUSTAINABLE SUPPLIER PROBLEM: A HYBRID DECISION MAKING MODEL BASED ON SWARA-WASPAS

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ABSTRACT. **Background:** The fierce competitive advantage in the global market depends largely on the integration of all supply chain networks. This network facilitates the movement of information and materials through the suppliers and end customers with a focus on planning and managing. This integration can result in the meeting demands of customer orders being affected by the performance of the suppliers. As a result of this integration, it can be considered that the performance of the suppliers is important in fulfilling customer orders on time. Evaluating and selecting suppliers is greatly influencing the performance of the supply network.

Methods: Selecting the proper supplier is a multi-criteria decision-making problem which includes both quantitative and qualitative criteria. A two-stage decision making method is proposed in the study under sustainability dimension. First, SWARA method is used to determine the relative importance of criteria and than WASPAS method is used to evaluate and rank the given alternatives.

Results: A real-life case study is given for the selected approach. Also, sensitivity analysis is given. This selected alternative confirms the preferences of decision makers as it is a company that operates internationally and has a reputation and awareness in sustainability within its own country.

Conclusions: Due to the increase in awareness on sustainability and the resulting regulations, the issue of sustainability in supply chains and sustainable supplier selection has become an important issue for companies. It is aimed to examine the supplier selection of a company in an electronics sector on a "sustainable" basis, considering from economic, environmental and social aspects. In this study, which was carried out to fill the literature gap identified in this field and to propose a systematic approach to sustainable supplier selection, a hybrid method which consists of both SWARA and WASPAS method have been used to evaluate the suppliers under the sustainability dimensions. With the help of a hybrid model, decision makers can manage conflict management of individual challenges using an analytical process.

Keywords: sustainable supplier selection, multi-criteria decision-making, SWARA, WASPAS.

INTRODUCTION

Supply chain management, which involves all activities related to the transformation and flow of goods and services from suppliers to ultimate users, and which represents the integration of all activities of a company, today has been expanded to a sustainable supply chain management to meet market constraints and demands from various stakeholders, to comply environmental legislations and to perform better [Büyüközkan and Çiftçi 2011, Ghadimi et al. 2017]. The increasing awareness of sustainability both in business world and society as a whole, companies want to include this issue in their supply chain activities to meet the requirements of increasing environmental and social legislation and to be able to cope with pressures from different stakeholder groups [Carter and Easton 2011, Azadnia et al. 2015].

Sustainability can be described as keeping the ability to be continual while diversity and productivity are maintained. According to Brundtland Report, sustainability is known as meeting today's needs without compromising

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the ability of future generations to meet their own needs. Sustainability includes topics such as ensuring world-wide safety, satisfying fundamental human needs, conservation of non-renewable natural resources, understanding environmental impact on both developing and industrialized economies and so on [Carter and Rogers 2008]. Studies denote that companies with high levels of sustainability achieve significant competitive advantages [Hollos et al. 2011]. This forces companies to quickly adapt to the economic goals as well as the processes that will achieve green and social goals. Which is why, companies which have realized that increasing sustainability ratings could be possible by integrating sustainability into their supply chain activities, have begun to implement sustainable supply chain management by combining sustainable development and supply chain management concepts [Azandia et al. 2012]. Designing and implementing sustainable supply chains, an important parameter of sustainability, is a critical issue for companies in competitive markets. To get ahead of such issues, companies have to build a supply chain structure for their economic, environmental and social targets [Mavi et al. 2017]. A sustainable supply chain can be defined as the management of materials, information and cash flows taking into account the objectives of the economic, environmental and social dimensions of sustainable development, as well as the management of cooperation between companies through the supply chain [Büyüközkan and Çiftçi 2011, Amindoust et al. 2012].

Today, companies that evaluate suppliers in cost-based are more likely to lose their competitive edge. For this reason, enriching and developing the operations are important by adding environmental and social dimensions [Ghadimi et al. 2017].

Selection of the supplier is known as a strategic decision within the scope of the supply chain management and has an important role in boosting the overall performance [Azadi and Saen 2012, Azadnia et al. 2015, Hashim et al. 2017]. In supply chain management, suppliers are very influential in assuming a critical role in achieving their goals and in determining the suppliers to cooperate with in the success of a chain. Sustainable supplier selection is the traditional supplier selection, including environmental and social dimensions to assess the performance of suppliers and to select the most appropriate one [Tavana et al. 2017]. Traditionally, companies use criteria like price, quality, flexibility while measuring supplier's performance. Today, sustainability factors are known to have a vital role of a supply chain in the long-term success. Many organizations are now talking about environmental, social and economic concerns and measuring their suppliers' sustainability performance [Govindan et al. 2013, Mehregan et al. 2014]. Suppliers are very important for sustainable supply chains [Büyüközkan and Çiftçi 2011]. The ability to manage a sustainable supply chain effectively depends on the success of all players and processes in the chain in terms of sustainability [Ghadimi and Heavey 2014] and depends on the number and quality of suppliers and customers and the relationship between environmental, economic and social dimensions. These relationships demonstrate the importance of suppliers' sustainable performance [Büyüközkan and Çiftçi 2011].

Supplier selection problem is to make selection by evaluating the performance of many suppliers in order to increase the efficiency of the whole supply chain system. Selecting the proper supplier is a multi-criteria decision making (MCDM) problem that requires a balance between conflicting quantitative and qualitative criteria [Azadnia et al. 2012].

In this study for sustainable supplier selection, a two stage MCDM method is preferred. Because of the effectiveness of calculating subjective criteria weights [Alrasheedi et al. 2021], SWARA method is chosen to determine the relative importance of criteria. The WASPAS method is used to evaluate and rank the alternatives. The main reason for using SWARA and WASPAS methods together, is the ease of application of them. While the SWARA method allows fewer pair-wise comparisons compared against other methods, the application of the WASPAS method is much easier [Urosevic et al. 2017].

This paper aims of the sustainable supplier selection to determine the most appropriate one with high potential to meet the needs of the electronics sector. Also with this study, filling the literature gap and proposing a systematic approach to sustainable supplier selection are aimed. The remainder of this paper is organized as follows. In the second section, literature review of the most related studies was summarized. In third section, proposed Step-Wise Weight Assessment Ratio (SWARA) and Weighted Aggregated Sum Product Assessment (WASPAS) methods were described in depth for the sustainable supplier selection. The steps of the proposed models were applied to a real case study in an electronics sector and the results were presented in the fourth section. The paper was finalized with the fifth section where the conclusions and suggestions for future studies were presented.

LITERATURE REVIEW

Traditionally, supplier selection process is evaluated by different tangible and intangible criteria like price, quality, technical competence and delivery performance. Cooperating with suppliers in environmentally, socially and economically strong has a positive effect on supply chain performance. For this reason, many companies have begun to incorporate the environmental, social and economic dimensions of sustainability into their supplier selection processes. The problem of sustainable supplier selection can be considered as a traditional supplier selection problem in which environmental and social criteria are taken into account in order to select suppliers and monitor their performance. There are many approaches in the literature that address the problem of selecting sustainable suppliers. It is known that MCDM methods are used the most among these approaches [Hashim et al. 2017]. For this reason, it is important to consider the studies involving MCDM methods which have already been carried out in the selection of sustainable suppliers.

Table 1. Criteria used in some of selecting sustainable supplier studies

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Author(s)
✓	✓	✓													Tirkolaee et al. 2020
✓	✓	✓													Jain et al. 2020
✓	✓	✓													Stevic et al. 2020
✓	✓	✓													Liu et al. 2019
✓															Bai et al. 2019
	✓		✓	✓	✓	✓									Segura et al. 2019
		✓					✓	✓							Mohammed et al. 2019
✓	✓	✓													Phochanikorn and Tan 2019
✓	✓	✓													Stevic et al. 2019
	✓	✓							✓	✓					Rabieh et al. 2019
✓	✓	✓													Pishchulov et al. 2019
✓	✓	✓													Abdel-Baset et al. 2019
✓	✓	✓													Matici et al. 2019
✓	✓	✓													Memari et al. 2019
✓	✓	✓									✓	✓			Awasthi et al. 2018
		✓					✓	✓							Mohammed et al. 2018
✓	✓	✓													Lu et al. 2018
✓	✓	✓													Kannan 2018
✓	✓	✓													Goren 2018
✓	✓	✓													Cheraghalipour and Farsad 2018
✓	✓	✓													Luthra et al. 2017
✓	✓	✓													Ahmadi et al. 2017
✓	✓	✓													Tavana et al. 2017
✓	✓	✓											✓		Mavi et al. 2017
✓	✓	✓													Amindoust and Saghafinia 2017
✓	✓	✓												✓	Girubha et al. 2016
✓	✓	✓													Azadnia et al. 2015
✓	✓	✓													Ghadimi and Heavey 2014
✓	✓	✓													Govindan et al. 2013
✓	✓	✓													Amindoust et al. 2012
✓	✓	✓													Azadnia et al. 2012

To this end, in this study, some of studies using at least one of MCDM methods for sustainable supplier selection/evaluation and published in the journals indexed in Web of Science between 2010 and 2020, have been reviewed. The reason for choosing 2010 as the start date is that the SWARA method used in this study was first introduced in this year. Table 1 shows main dimensions under sustainability used in these studies. This table has been prepared according to the dimensions on the basis of authors since there is no standard definition of the criteria that have been. Abbreviations used in the title of the table are defined as follows: 1-Economic, 2-Environmental, 3-Social, 4-Food safety, 5-Logistic, 6-Product quality, 7-Commercial, 8-Conventional, 9-Green, 10- Cost economic, 11-Non-cost economic, 12-Quality of relationship, 13- Global risks, 14-Risk, 15-Business.

This study will be one of the rare studies using SWARA and WASPAS methods together to evaluate the most appropriate sustainable supplier for a company.

METHODOLOGY

Supplier selection can be determined as a complex MCDM problem that needs to address both quantitative and qualitative criteria while evaluating alternatives. As it is mentioned in Introduction section, there are many approaches used in sustainable supplier selection. A two-steps approach is preferred in this study. Firstly, criteria weights are calculated with SWARA method and then supplier alternatives are ranked using WASPAS method. The methods used in this study are described below.

Step-Wise Weight Assesment Ratio (SWARA) Method

The SWARA method has been often used recently, was first introduced by Kersuliene et al. [2010]. The SWARA method allows decision makers to choose their own preferences, based on the current environmental and economic situations. In addition, the role of decision makers is even more important in this method [Zolfani et al. 2013]. This method which intitles to decision makers to exclude the criteria that they think is insignificant, allows for each individual DM to create their own rankings for the criteria and weight them [Zolfani et al. 2018]. For these reasons, determining the decision makers is a critical activity.

With ease of application of SWARA many decision makers, working in different areas can easily get into contact with each other [Zolfani et al. 2013, Jamal et al. 2015]. SWARA method's viewpoint is different from other MCDM models. The most distinct difference of the SWARA method when compared to AHP and ANP methods is that the decision makers decide on their own on the priority of each criterion. This method, which can be easily used in unusual and complex situations, should be based on needs and circumstances [Khodadadi et al. 2017]. The SWARA method requires less pair-wise comparisons than the AHP method. This simplicity also describes the SWARA method as a more attractive and an easier method [Urosevic et al. 2017]. Also, in the SWARA method, there is no scale that DMs required to use, so they can express their opinions more freely.

Another advantage of this method is that the prioritization of some problems is base on the policies of companies or countries and that there is no need for any evaluation in sorting criteria [Zolfani et al. 2013]. But this method does not provide any structure to check the consistency of the comparisons. The steps of SWARA method are as follows [Khodadadi et al. 2017]:

Step 1: All criteria are sorted by importance using decision makers' opinions.

Step 2: Starting from the second criterion, the relative importance levels for each criterion are determined. The comparative importance of the average values of j is obtained as a relative importance in compliance with $(j-1)$. criterion. It's indicated by s_j.

Step 3: k_j coefficient is determined.

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases} \quad (1)$$

Step 4: w_j is recalculated.

$$w_j = \begin{cases} 1 & j = 1 \\ \frac{x_{j-1}}{k_j} & j > 1 \end{cases} \quad (2)$$

Step 5: The criteria weights are obtained.

$$q_j = \frac{w_j}{\sum_{k=1}^{n} w_j} \quad (3)$$

q_j is the relative weight of the criterion j and n is the number of criteria.

Weighted Aggregated Sum Product Assessment (WASPAS) Method

WASPAS method based on the combination of Weighted Sum Model (WSM) and Weighted Product Model (WPM) was developed by Zavadskas et al. in 2012. It has been proven that this combined method is better in terms of accuracy than the accuracy of individual methods [Zolfani et al., 2013]. This method's first phase is constructing a decision matrix, $X = [x_{ij}]_{mxn}$ where x_{ij} is the evaluation value of the i^{th} alternative with respect to the j^{th} criterion, m is the number of alternatives and n is the number of evaluation criteria. The steps of WASPAS method are as follows [Khodadadi et al., 2017]:

Step 1: Normalization of the initial decision matrix.

$$\bar{x}_{ij} = \frac{x_{ij}}{opt_i x_{ij}} \quad \text{where } i = \overline{1,m}\,; j = \overline{1,n} \quad (4)$$

If opt value is max.

$$\bar{x}_{ij} = \frac{opt_i x_{ij}}{x_{ij}} \quad \text{where } i = \overline{1,m}\,; j = \overline{1,n} \quad (5)$$

If opt value is min.

Step 2: Calculation of WASPAS weighted and normalized decision matrix based on weighted sum method.

$$\bar{\bar{x}}_{ij,sum} = \bar{x}_{ij} q_j \quad \text{where } i = \overline{1,m}\,; j = \overline{1,n} \quad (6)$$

Step 3: Calculation of WASPAS weighted and normalized decision matrix based on weighted product method.

$$\bar{\bar{x}}_{ij,mult} = \bar{x}_{ij}{}^{q_j} \quad \text{where } i = \overline{1,m}\,; j = \overline{1,n} \quad (7)$$

Step 4: Calculation of evaluation and priorization of alternatives.

$$WPS_i = 0.5 \sum_{i=1}^{n} \bar{\bar{x}}_{ij} + 0{,}5 \prod_{i=1}^{n} \bar{\bar{x}}_{ij}$$

where $i = \overline{1,m}\,; j = \overline{1,n}$ (8)

This method has been widely applied and also extended by integrating with other MCDM methods in decision making problems. Through a comprehensive literature search in the Web of Science, SWARA and WASPAS methods were used together in some studies. But in the view of sustainability this study will be one of the rare studies using SWARA - WASPAS to rank the suppliers.

ILLUSTRATIVE EXAMPLE

Top management of a company operating in the electronics sector that wants to assimilate and sustain sustainability in the face of environmental and social awareness, legal pressures and the sensitiveness of both employees and managers, has been planned sustainability process intrinsically and has begun to transform its activities into sustainability gradually. However, top management has also pressured the stakeholders of the company to work with the same vision of sustainability. The company wants to continue with those that are sustainable and to evaluate the existing and potential suppliers operating both within the country and internationally and to isolate their ways with those who do not want to adopt sustainability. Under these circumstances, company first focused to determine the criteria affecting sustainable supplier selection.

When dealing with the problem of sustainable supplier selection, firstly a team consisting of decision makers working in the purchasing department and also academicians was organized. The most important goal of the comprehensive literature review is to be able to show as a whole the criteria under the dimensions of sustainability and to prevent the decision makers to have dilemma (Table 1).

After a thorough literature review and the results of many interviews, criteria affecting the selection of sustainable suppliers were identified and accepted by the decision-making team taking into account the sector, the company and suppliers. The model of the study was established (Figure 1). Briefly, decision makers have been included in three important phases of this study. The first stage is the phase of the establishing the model and determining the criteria. In the second phase, the evaluation of the criteria by SWARA method was also carried out by including decision makers. The final phase is evaluation of the alternatives by WASPAS method.

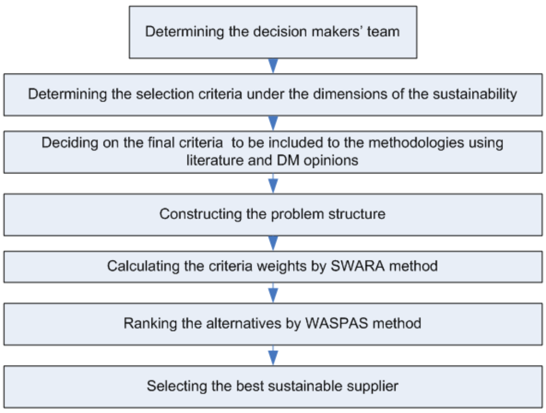

Fig. 1. Model of the study

Sustainable supplier selection can be defined as a supplier selection problem in which, among economic, environmental and social criteria are considered to evaluate a supplier's performance. One of the most important steps of a supplier selection problem is to specify the selection criteria and techniques. In the literature, many criteria are used in the selection of sustainable suppliers under the economic, environmental and social dimensions of sustainability. At this stage of the study, the criteria under these dimensions are summarized for evaluating sustainable suppliers.

The criteria used in this study are as follows:

Economic dimension: Traditionally in supplier selection, cost, price etc. are used under this dimension. In this paper criteria of cost (C_1), quality (C_2), inventory level reduction (C_3), on-time delivery (C_4) and productivity (C_5) criteria are preferred for economic dimension.

Environmental dimension: Companies which are aware of the environmental impact of production, pay special attention for evaluating the suppliers' environmental performance [Azadnia et al. 2015]. Criteria of green technology capabilities (C_6), reduction of the use of hazardous materials (C_7), eco-efficient transportation vehicles (C_8), green packaging and labeling (C_9), waste management and pollution prevention (C_{10}) and environment management system (C_{11}) are determined for environment dimension.

Social dimension: In last decades, companies realized the essentiality to add social responsibility issues to their supply chain activities because of increasing pressures. In this study, for social dimension, work safety and labor health (C_{12}), the right of stakeholders (C_{13}), local communities influence (C_{14}), community development (C_{15}) and rights of employee (C_{16}) are preferred.

Table 2. Criteria ranks and criteria weights

	DM_1	DM_2	DM_3	DM_4	DM_5	q_j
C_1	1	2	3	1	1	0,168
C_2	3	1	1	3	2	0,156
C_3	4	3	2	2	4	0,129
C_4	2	5	6	4	3	0,110
C_5	7	4	5	6	5	0,086
C_6	11	7	4	5	6	0,066
C_7	8	8	7	7	7	0,057
C_8	9	10	8	8	8	0,046
C_9	10	11	9	9	9	0,040
C_{10}	5	15	10	11	13	0,037
C_{11}	6	12	11	10	12	0,039
C_{12}	15	6	12	12	11	0,032
C_{13}	16	16	16	16	16	0,019
C_{14}	14	14	15	14	14	0,023
C_{15}	13	13	14	13	15	0,025
C_{16}	12	9	13	15	10	0,028

In order to determine the importance levels of all criteria, the decision makers ranked each criterion individually, from the most importantly to the least significant from 1 (the most important) to 16 (the least important). The ranking results are shown in Table 2.

The most striking feature in Table 2 is that economic criteria for all decision makers are overriding. Also weights of criteria (q_j) is illustrated in Table 2 using the Equations (1) - (3).

According to the results obtained by DMs, the criterion with the highest importance is the cost criterion under the economic dimension. The result is not surprising when we look at the first three criteria according to the order of importance. All of these criteria are under the economic dimension. As well as criteria under the environmental dimension appear to have medium importance, rights of employee under social dimension are the least important criterion. All criteria under social dimension are at the bottom of this sorting.

After the weights of the criteria were calculated by SWARA method, the alternatives were evaluated using the WASPAS method. Therefore, the decision-making group ranked the suppliers on the basis of the purchasing costs and amount of usage and they selected four alternatives, two of them are domestic, in the WASPAS method. DMs assessed these four alternatives using the criteria according to their know-how in relation to their suppliers, knowledge and experience. Thus, the decision matrix was obtained. The decision matrix has been normalized by taking into account the cost and benefit criteria (Table 3). In this study, C_1 and C_3 are cost criteria.

Table 3. Normalized Decision Matrix

	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**
A_1	0,67	0,71	0,80	1,00	0,83	1,00	0,67	0,60
A_2	0,80	0,57	0,80	1,00	0,83	0,86	1,00	1,00
A_3	0,80	0,43	1,00	0,67	0,67	0,86	1,00	1,00
A_4	1,00	1,00	1,00	0,83	1,00	0,57	0,33	0,80
Criteria weight	**0,1681**	**0,1564**	**0,1289**	**0,1102**	**0,0858**	**0,0663**	**0,0569**	**0,0458**
	C_9	**C_{10}**	**C_{11}**	**C_{12}**	**C_{13}**	**C_{14}**	**C_{15}**	**C_{16}**
A_1	0,86	0,60	0,83	1,00	0,57	0,83	0,60	0,86
A_2	1,00	1,00	0,83	0,83	0,86	0,67	1,00	1,00
A_3	0,71	1,00	0,67	0,83	0,57	0,83	1,00	0,71
A_4	0,57	0,80	1,00	0,50	1,00	1,00	0,80	0,57
Criteria weight	**0,0339**	**0,0393**	**0,0369**	**0,0323**	**0,0280**	**0,0251**	**0,0230**	**0,0188**

Table 4. Alternatives Evaluation with Different λ Values

	λ=0	**λ=0,1**	**λ=0,2**	**λ=0,3**	**λ=0,4**	**λ=0,5**	**λ=0,6**	**λ=0,7**	**λ=0,8**	**λ=0,9**	**λ= 1**
A_1	0,809	0,806	0,803	0,801	0,798	0,795	0,793	0,790	0,787	0,785	0,782
A_2	0,848	0,845	0,843	0,840	0,838	0,835	0,833	0,830	0,828	0,825	0,822
A_3	0,723	0,721	0,719	0,718	0,716	0,714	0,712	0,711	0,709	0,707	0,706
A_4	0,815	0,814	0,813	0,811	0,810	0,809	0,808	0,807	0,805	0,804	0,803

The total relative importance of the alternatives is calculated with both WSM and WPM methods using Equation (6) and (7). The criteria weights used at this stage of the study are the weights obtained from the SWARA method in the previous stage. The final relative importance for each alternative is calculated by Equation (8). Different λ values are used in evaluating alternatives (Table 4).

When Table 4 is analyzed, it is seen that the order of the alternatives does not depend on the λ value. In the order of sustainable suppliers, the first place has been the A_2 supplier, whose business is internationally engaged and whose sustainability awareness is high. The second place has been A_4 and the last has been A_3 alternative.

In the study, the supplier rank obtained depending on the criterion weights determined by the evaluations performed subjectively and therefore the decision-making consistency was examined by sensitivity analysis. Although the order of sustainable supplier alternatives may change depending on different decision makers, A_2 has been chosen as the best alternative.

CONCLUSIONS

Global warming, climate change, decreasing non-renewable energy sources and other issues about the environment have a serious impact on companies just like every individual has on. All these problems highlight the concept of sustainability. Nowadays companies feel compelled to consider and realize sustainability in terms of environmental, social and economic aspects. As a consequence, the importance of considering the sustainability in the supply chains has increased. Designing and implementing a sustainable supply chain which is an important parameter of sustainability, is an important issue for companies in competitive markets [Mavi et al. 2017].

Due to the increase in awareness on sustainability and the resulting regulations, the issue of sustainability in supply chains and sustainable supplier selection has become an important issue for companies. As it is known, supplier selection is one of the most important problems of supply chain management. The selection of traditional suppliers is based on criteria more like price, quality, service and so on. Nowadays, it has been seen that companies, stakeholders and governments have changed the way in which they view sustainability and adopted the vision of sustainability, not merely to use economic criteria and to evaluate the alternatives [Ghadimi and Heavey 2014]. This study proposes a sustainable and systematic approach to the sustainable supplier selection using the two-stage SWARA-WASPAS approach.

As the importance of sustainability in economic, environmental and social dimensions in the national and international markets becomes indispensable for competition, companies have to make all their business processes "sustainable" in order to adapt their own processes to this awareness, to meet the expectations of their customers and to fulfill legal obligations. Therefore, companies now have to act with the motto of sustainability throughout the entire value chain. Based on these facts, in this study, it is aimed to determine the indispensable criteria for a company in the electronics sector to provide "sustainable" conditions among the suppliers, to select the most suitable one among them based on these criteria and to rank the suppliers.

In this study, a set of appropriate sustainable criteria has been derived a rigorous literature search and in the light of expert opinions and a new model has been proposed for sustainable supplier selection for a company in the electronics sector. The main contribution of this paper is to select the most appropriate sustainable supplier among alternatives using both qualitative and quantitative criteria using SWARA and WASPAS methods under sustainability dimensions. Among the criteria under sustainability dimensions, cost criteria under economic dimension receives the top ranking. The result is not surprising as many companies consider economic factors even more important in terms of sustainability. When we list the criteria in order of importance, the criteria under the economic dimension in the first place and the social dimension in the last place can be evaluated as a result of not perceiving the importance of sustainability in the desired level and not paying attention. When the alternative ranking and the selection of the most appropriate calculated by WASPAS method is considered, it is determined that A_2 alternative is the supplier closest to the sustainability concept of the company. This alternative confirms the preferences of decision makers as it is a company that operates internationally and has a reputation and awareness in sustainability within its own country. As a result of the sustainable supplier evaluation with the WASPAS method, the ranking of four suppliers was obtained as $A_2 > A_4 > A_1 > A_3$. Sensitivity analysis was also performed.

As in all academic research, this research has also some limitations as well which create new study areas for further researches. 16 criteria have been determined for sustainable supplier selection, and when other criteria are added to the study or the selected ones are removed, the ranking may be changed. As is known, the results may vary according to the selected criteria. In this paper the most important criteria were selected based on the decision makers opinions, another study can be establishing a new model with other criteria and can evaluate alternatives disparately. The study findings are referred to a single company in a single sector so it isn't right to generalize the findings. Fuzziness was not considered in this study. In future studies, the method can be re-evaluated in a fuzzy environment. In addition, other MCDM methods can be applied in the study. Moreover, this model could be further investigated in other industries and researchers should pay more attention to supplier selection for different industries. In addition, increasing both the number of criteria and the number of decision makers will yield practical results. Also, order allocation of suppliers can be examined in future studies. It is thought that this study will contribute not only to the decision makers but also to the academicians who carry out sustainable supplier selection.

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