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A NOVEL HYBRID SWARA AND VIKOR METHODOLOGY FOR SUPPLIER SELECTION IN AN AGILE ENVIRONMENT

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Abstract. The concept of the agile supply chain has been taken into account as means of achieving a high competitive edge in rapidly changing business environments. Supply partner selection is one of the most appealing issues for agile supply chain management, which have recently been studied by academicians and practitioners. Due to a large number of factors to be considered, supplier selection process is a difficult task for every company. Therefore, supplier selection process can be viewed as a multiple attribute decision-making (MADM) problem. In this paper, a novel hybrid MADM method is proposed for agile supplier selection based on four criteria including performance, cost, flexibility and technology. Two MADM methods, including step-wise weight assessment ratio analysis (SWARA) and Vlse Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR) are applied in decision-making process. More precisely, SWARA is used for determining the importance of each criterion and calculating their weights and VIKOR is applied for evaluating alternatives as well as ranking supplier alternatives from the best to the worst. More precisely, the first phase of the proposed methodology, step-wise weight assessment ratio analysis (SWARA), is useful for determining the importance of each criterion and calculating the weight of each criterion, and the second phase with Vlse Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR) is useful for evaluating alternatives as well as ranking supplier alternatives from the best to the worst. Finally, a real case-study is presented to demonstrate the applicability of the proposed methodology. As a result, the model can help managers to evaluate and select the best supplier regarding own company strategies, resources, policies and etc. for their organization.

Keywords: selection, multiple criteria analysis, method, system, MCDM.

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Introduction

Supply chain management (SCM) is considered as one of the most important aspects of production planning and control (Yigin *et al.* 2007) and it has recently been taken into account by managers and researchers. The main aim of SCM is to manage multiple relationships across the supply chain (SC) regarding the entire flow of information, materials, and services to fulfil customer demands in an efficient manner (Li, Wang 2007). Supply chains comprise potential suppliers, producers, distributors, retailers and customers and etc. In this context, suppliers have an important role in achieving the goal of supply chain management. In this regard, the integration of strategic partnership with suppliers with better performance is recommended within the SC, while it leads to enhanced performance of the chain in many directions such as costs reduction through waste elimination, continuous improvement of quality to achieve zero defects, flexibility improvement to meet the end-customer requirements, decrease lead time at different stages of the SC (Amin, Razmi 2009).

Besides, the concept of agile supply chains (ASC) or networks has recently attracted many businesses to efficiently and effectively respond to increasingly dynamic and volatile markets. Whenever a dynamic network of companies is formed, an agile supply chain is likely to need to change frequently in response to rapidly changing business environments (Wu *et al.* 2009). In ASC, the alignment of companies with their supply partners is suggested, which leads to improved efficiency of their operations, as well as working together to achieve the necessary levels of agility throughout the entire supply chain (Wu, Barnes 2011). Therefore, among different ASC issues, supply partner selection process becomes more crucial to survive in today's highly competitive and global environment.

Moreover, there is a wide set of reasons to regard supplier selection process as the most appealing issue, to which numerous researches have been dedicated. The repetitive nature of supplier selection process and frequently changing customer demands lead to the increase in the uncertainty and ambiguity of this decision-making process, particularly in ASC. Therefore, in order to achieve the successful operation of an ASC, an effective supply partner selection becomes an essential process that may enhance effectiveness, efficiency, quality, safety and profit. It should be noted that the importance and complexity of partner selection has increased (Sarkar, Mohapatra 2006). ASC partner selection has been defined as a process for identification of an efficient combination of suppliers, producers and distributors, depending on which the right mix and quantity of products and services are provided to customers (Talluri, Baker 2002). In an ASC, determination of key components of the supply network – e.g. suppliers, producers, distribution centres, etc. — can be an extremely complex task just as well as specification of their combination. In addition, demanding and dynamic market conditions, in which organizational decision-makers may have to consider a wide set of selection criteria such as performance, cost, flexibility (Cagliano *et al.* 2004) may change over time. Other important reasons of the supplier selection issue could be listed as follows: the product quality which depends on the organization's suppliers, the existence of several suppliers that offer a wide range of choices for selecting supplier alternatives. Hence, the partner selection process should be done quickly as well as thoroughly (Arteta, Giachetti 2004).

Supplier selection problem has been expressed as a complex decision-making process in nature due to variant parameters and diverse aspects (Xia, Wu 2007; Razmi *et al.* 2009). In this regard, the authors propose supplier selection process in agile environments as a multiple attribute decision-making (MADM) problem. MADM approaches one of the major categories of multiple criteria decision-making (MCDM) methods and deals with the evaluation and selection of an alternative among other alternatives (Zavadskas *et al.* 2009, 2010). As Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) (Hwang, Yoon 1981), Elimination and Choice Translating Reality (ELECTRE) (Roy 1968), MUSA (Grigoroudis, Siskos 2002), Vlse Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR) (Opricovic 1998), Complex Proportional Assessment (COPRAS) (Zavadskas, Kaklauskas 1996), Complex Proportional Assessment with Grey relations (COPRAS-G) (Zavadskas *et al.* 2008, 2009), Additive Ratio Assessment (ARAS) (Zavadskas, Turskis 2010; Zavadskas *et al.* 2012), Step-wise Weight Assessment Ratio Analysis (SWARA) (Keršulienė *et al.* 2010), Factor Relationship (FARE) (Ginevicius 2011) are the prominent MADM techniques in the related literature.

Inclusive complex criteria used in multi-stage decision-making process are apposite for solving many problems (Zavadskas *et al.* 2012; Tamošaitienė *et al.* 2013; Tamošaitienė, Gaudutis 2013).

In this paper, the authors attempt to provide a novel hybrid MADM methodology for supplier selection in agile environments. The proposed model comprises SWARA and VIKOR techniques for agile supplier selection in order to respond to increasingly volatile markets and survive in the highly competitive manufacturing milieus. Firstly, the SWARA method is implemented to obtain the weights of agility criteria. And then, the VIKOR method is used for evaluation and selection of the best/agile supplier alternative according to the agility level of an organization.

The rest of the paper is structured as follows: Section 1 presents the proposed integrated approach model, and SWARA and VIKOR methods are elaborated as well. In Section 2, a real case-study is analysed to validate the proposed model. Also, the proposed decision-making SWARA and VIKOR results are presented in Section 2. Finally, some remarks and future research directions are provided in the final section.

1. Proposed integrated SWARA–VIKOR methodology

In today's dynamic manufacturing milieus, enterprises deal with dramatic and often unexpected changes, such as the increase of product variety and complexity, shorter time frames to respond, and the continual need to gain new capabilities through innovativeness (Sari *et al.* 2008). In this era, companies must use every opportunity for performance improvement. To do so, a close relationship between a firm and its supply chain partners has been recommended to optimize its business processes (Wu, Barnes 2011). Furthermore, the required products are changed frequently as well as some partners. Hence, supplier selection process as a key step in the formation of any supply chains and especially in the agile supply chains, which are frequently reconfigured, is to be studied applying effective techniques (Sari *et al.* 2008).

Supply partner selection process is a multi-attribute decision-making problem that comprises both qualitative and quantitative factors. Consequently, a variety of reasons exist for using MADM approaches for selecting an alternative. Firstly, MADM methods deal with the selection process of the best alternative among candidates that is done upon decision-maker preferences with respect to many conflicting/contradictory qualitative and quantitative multiple criteria. Secondly, determination and evaluation of all these factors is a difficult task.

The aim of this paper is: using MADM approaches to assess and choose the best supplier for a manufacturing company that produces a variety of products. Therefore, the authors attempt to propose a bi-level hybrid structure of the new multiple-attribute decision-making (MADM) methods to discuss supplier selection process for the first time in agile supply chains. The supposed integrated approach involves two MADM procedures; Step-wise Weight Assessment Ratio Analysis (SWARA) and Vlse Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR). In the first level, SWARA technique is devoted to calculation of the weight of a criterion and then, VIKOR is proposed to rank agile supplier alternatives from the best to the worst. Fig. 1 describes the evaluation procedure of this study, which consists of three main phases:

Phase I. After establishing the decision-making team, the most important criteria for supplier selection is identified. Next, the qualitative and quantitative criteria are defined. Finally, the project team constructs the selection criteria and problem structure.

Based upon a comprehensive review of partner evaluation process, and measurement of organizations agility, the authors propose the four main criteria including performance (as a combination of quality, time, and progress), cost (as a combination of caution cost, capital expenditure, and operational expenditure), flexibility (including product flexibility, product volume flexibility, multi-skilled and flexible people, establishment flexibility, manufacture flexibility), and finally – technology that is measured in terms of technical features/characteristics, system reliability/availability, system redundancy, compliance with international standards, interoperability with other systems, future technology development (Sharifi, Zhang 1999; Tam, Tummala 2001; Tsourveloudis, Valavanis 2002; Lin *et al.* 2006; Luo *et al.* 2009; Buyukozkan, Cifci 2011) that contribute to the goal. Fig. 2 represents the selection criteria and problem structure. As depicted in Fig. 2, on the next level are four criteria that are decomposed into numerous sub-criteria and some of the proposed sub-criteria are also divided into some other sub-criteria.

The quality dimension is decomposed into three sub-criteria including the product quality (Sharifi, Zhang 1999; Luo *et al.* 2009), which is measured by means of the ratio of the defected product to the all product, service level (Wu *et al.* 2009; Luo *et al.* 2009), and information quality (Buyukozkan, Cifci 2011), which is measured in terms of information accessible to beneficiary (Luo *et al.* 2009), perfect degree of enterprise information system (Lin *et al.* 2006).

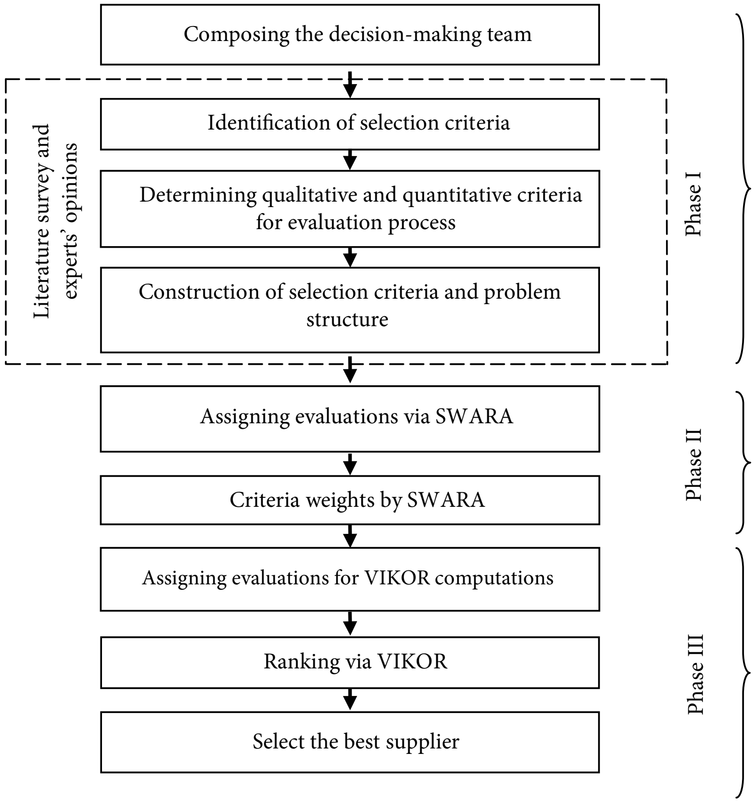

Fig. 1. The evaluation procedure

The time dimension comprises delivery time (Sari *et al.* 2008; Buyukozkan, Cifci 2011), on-time response to request (Buyukozkan, Cifci 2011), distribution time, and transportation time (Wu *et al.* 2009). The progress criterion is assessed upon customer satisfaction as well as customer-driven innovations (Sharifi, Zhang 1999).

The cost dimension is a combination of caution cost, which is evaluated by means of risk or commitment (Sari *et al.* 2008), capital expenditure and operational expenditure (Tam, Tummala 2001). It must be noted that raw material cost is suggested as a sub-criterion of the capital expenditure criterion, since the whole ASC seeks to minimize the cost of raw material, which is supplied by various suppliers. Moreover, since the whole ASC seeks to minimize the production costs (Wu *et al.* 2009), which are provided by manufacturing plants, they are regarded as operational expenditure. Besides, operational expenditure is evaluated depending on maintenance cost and support system cost (Tam, Tummala 2001).

The flexibility criterion is categorized into product flexibility (Sharifi, Zhang 1999), product volume flexibility (Tsourveloudis, Valavanis 2002), multi-skilled and flexible people (Sharifi, Zhang 1999) including sub-criteria continuous training and development (Tsourveloudis, Valavanis 2002) and establishment flexibility, which expresses the complexity and flexibility

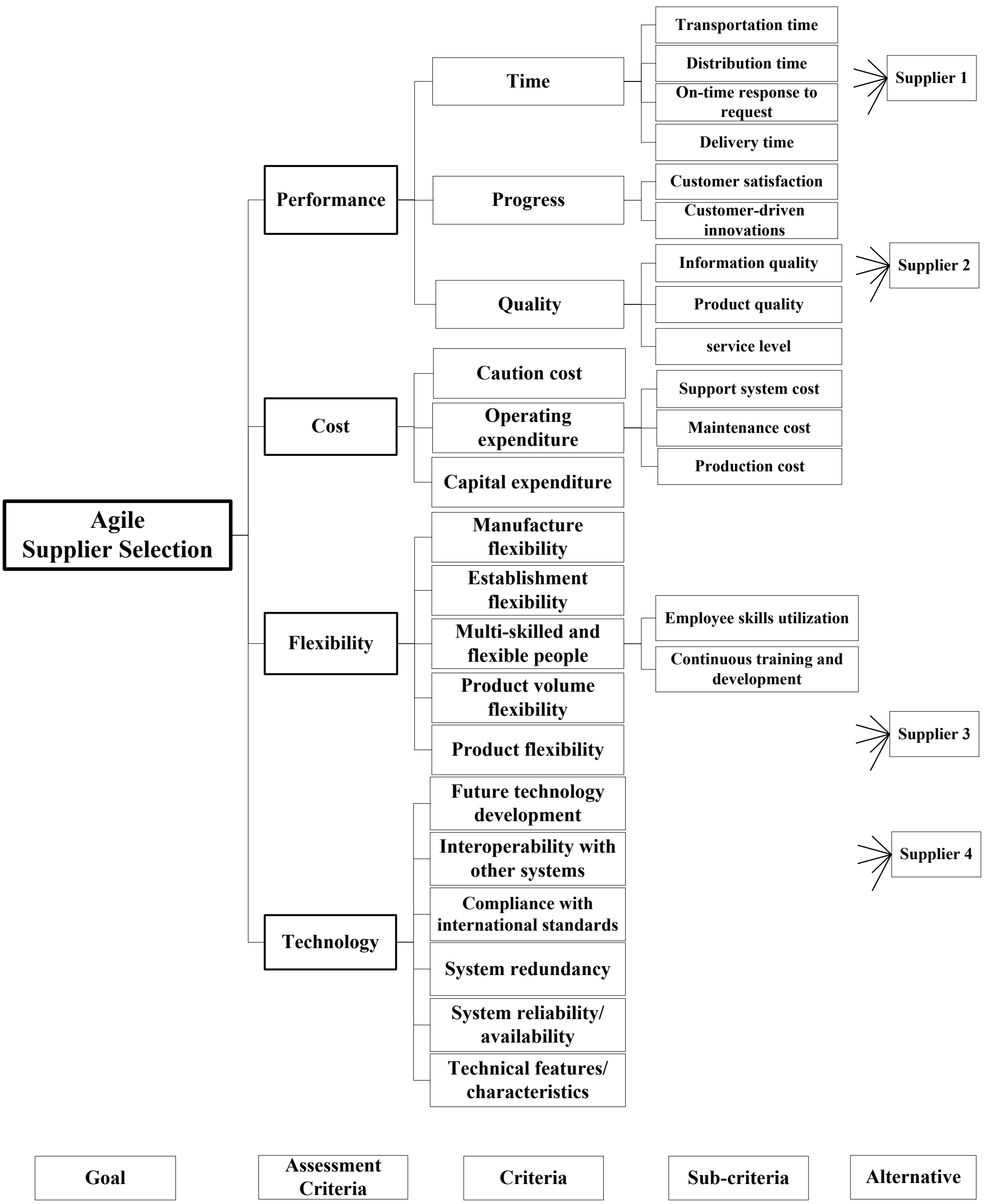

Fig. 2. Problem structure, selection aspects and formulated alternatives

of building new relationships as well as breaking up old relationships (Wu *et al.* 2009), manufacture flexibility that is appraised according to concurrent execution of activities (Tsourveloudis, Valavanis 2002; Lin *et al.* 2006).The proposed criteria related to the agile supplier selection problem are presented in Table 1.

Table 1. Factors taken from the review of the related literature and relevant to supplier evaluation and selection in an agile supply chain

No.	Criteria and sub-criteria	Related literature source
$\boldsymbol{X}_1$	**Performance**	
$X_{1\text{-}1}$	**Quality**	
$X_{1\text{-}1\text{-}1}$	*product quality*	Wu *et al.* (2009); Luo *et al.* (2009)
$X_{1\text{-}1\text{-}2}$	*service level*	Wu *et al.* (2009); Luo *et al.* (2009)
$X_{1\text{-}1\text{-}3}$	*information quality*	Buyukozkan, Cifci (2011)
$X_{1\text{-}2}$	**Time**	
$X_{1\text{-}2\text{-}1}$	*delivery time*	Sari *et al.* (2008); Buyukozkan, Cifci (2011)
$X_{1\text{-}2\text{-}2}$	*on-time response to request*	Luo *et al.* (2009); Buyukozkan, Cifci (2011)
$X_{1\text{-}2\text{-}3}$	*distribution time*	Wu *et al.* (2009)
$X_{1\text{-}2\text{-}4}$	*transportation time*	Wu *et al.* (2009)
$X_{1\text{-}3}$	**Progress**	
$X_{1\text{-}3\text{-}1}$	*customer satisfaction*	
$X_{1\text{-}3\text{-}2}$	*customer-driven innovations*	Sharifi, Zhang (1999)
X_2	**Cost**	
$X_{2\text{-}1}$	Caution cost	Sari *et al.* (2008)
$X_{2\text{-}2}$	Capital expenditure	Tam, Tummala (2001); Wu *et al.* (2009)
$X_{2\text{-}3}$	Operational expenditure	
$X_{2\text{-}3\text{-}1}$	*production cost*	Wu *et al.* (2009)
$X_{2\text{-}3\text{-}2}$	*maintenance cost*	Tam, Tummala (2001)
$X_{2\text{-}3\text{-}3}$	*support system cost*	Tam, Tummala (2001)
X_3	**Flexibility**	
$X_{3\text{-}1}$	Product flexibility	Sharifi, Zhang (1999)
$X_{3\text{-}2}$	Product volume flexibility	Tsourveloudis, Valavanis (2002)
$X_{3\text{-}3}$	Multi-skilled and flexible people	
$X_{3\text{-}3\text{-}1}$	*continuous training and development*	Tsourveloudis, Valavanis (2002)
$X_{3\text{-}3\text{-}2}$	*employee skills utilization*	
$X_{3\text{-}4}$	Establishment flexibility	Wu *et al.* (2009)
$X_{3\text{-}5}$	Manufacture flexibility	Tsourveloudis, Valavanis (2002); Lin *et al.* (2006)
X_4	**Technology**	

Continued Table 1

No.	Criteria and sub-criteria	Related literature source
$X_{4\text{-}1}$	**Technical features/ characteristics**	Sharifi, Zhang (1999); Buyukozkan, Cifci (2011)
$X_{4\text{-}2}$	**System reliability/availability**	Tam, Tummala (2001); Lin *et al.* (2006)
$X_{4\text{-}3}$	**System redundancy**	Tam, Tummala (2001)
$X_{4\text{-}4}$	**Compliance with international standards**	Tam, Tummala (2001); Luo *et al.* (2009)
$X_{4\text{-}5}$	**Interoperability with other systems**	Tam, Tummala (2001); Tsourveloudis, Valavanis (2002)
$X_{4\text{-}6}$	**Future technology development**	Sharifi, Zhang (1999); Tam, Tummala (2001)

Phase II. Criteria weights were calculated by applying SWARA method and based on expert evaluations.

Phase III. In this stage, all alternatives were evaluated by the project team and VIKOR method was applied to achieve the final ranking results.

The following weight assessment approaches are among those listed in the literature: Entropy (Shannon 1948; Sušinskas *et al.* 2011; Keršulienė, Turskis 2011), FARE (Ginevicius 2011), SWARA (Keršulienė *et al.* 2010), etc. SWARA method is one of the brand-new ones. In this method, an expert plays an important role on evaluations and calculation of weights. Also, each expert chooses the importance of each criterion. Next, each expert ranks all criteria from the first to the last. An expert uses his or her own implicit knowledge, information and experiences. Based on this method, the most significant criterion is given rank 1, and the least significant criterion is given rank last. The overall ranks to the group of experts are determined according to the mediocre value of ranks (Keršulienė, Turskis 2011). The ability to estimate experts' opinion about importance ratio of the criteria in the process of their weights determination is the main element of this method (Keršulienė *et al.* 2010). Moreover, this method is helpful for coordinating and gathering data from experts. Furthermore, SWARA method is uncomplicated and experts can easily work together. The main advantage of this method in decision-making is that in some problems priorities are defined based on policies of companies or countries and there is no need for evaluation to rank criteria. In other methods, such as AHP or ANP, the model is created based on criteria and expert evaluations will affect priorities and ranks (Zavadskas *et al.* 2011; Hashemkhani Zolfani *et al.* 2012). So, SWARA can be useful for some issues with known priorities depending on a situation; and finally, SWARA is proposed in a certain environment of decision-making. All developments of decision-making models based on SWARA method are as follow: Keršulienė *et al.* (2010) in selection of rational dispute resolution method; Keršulienė, Turskis (2011) for architect selection; Hashemkhani Zolfani *et al.* (2013a) in design of products; Aghdaie *et al.* (2013) in the machine tool selection; Hashemkhani Zolfani *et al.* (2013b) in selecting the optimal alternative of mechanical longitudinal ventilation of tunnel pollutants; Hashemkhani Zolfani *et al.* (2013c) in investigating the success factors of online games based on explorer.

VIKOR method

The VIKOR method is a compromise MADM method, developed by Opricovic, Tzeng (Opricovic 1998; Opricovic, Tzeng 2002). The concept of VIKOR is based on the compromise programming of MCDM by comparing the measure of "closeness" to the "ideal" alternative (Wu *et al.* 2009). The VIKOR method can provide a maximum "group utility" for the "majority" and a minimum of an individual regret for the "opponent" (Opricovic 1998; Opricovic, Tzeng 2002, 2004).

The recent developments of decision-making models based on VIKOR method are listed below: Fouladgar *et al.* (2012) in project portfolio selection, Yücenur and Demirel (2012) for insurance company selection, Wang and Tzeng (2012) for creating brand value, Liu *et al.* (2012) in improvement of tourism policy implementation, Wu *et al.* (2012) for ranking universities, Antucheviciene *et al.* (2011) in ranking of building redevelopment alternatives.

2. Case study

A real case study problem has been chosen to show the performance and application of the model. The study was conducted by a well-known company in manufacturing automobile industry. This company is located near Tehran, in Iran and it is a large manufacturing company with more than 500 employees. Besides, it is one of the biggest suppliers for both Saypa and Zamyad automobile manufacturing companies. Recent fast changes in automobile market environment and customer needs have been combined with high competitiveness in this market place. Therefore, the company has decided to use analytical tools for evaluation and selection of its suppliers. After defining a new project for evaluation and selection of suppliers, a project team of two industrial engineers, two managers and CEO of the company was established (see Table 2). This team identified four potential suppliers as alternatives for evaluation. The alternatives denoted as A_1, A_2, A_3, and A_4, respectively.

Among all criteria ten criteria $X_{1\text{-}1\text{-}1}$, $X_{1\text{-}1\text{-}2}$, $X_{1\text{-}1\text{-}3}$, $X_{1\text{-}1\text{-}4}$, $X_{2\text{-}1}$, $X_{2\text{-}2\text{-}1}$, $X_{2\text{-}2\text{-}2}$, $X_{2\text{-}2\text{-}3}$, $X_{4\text{-}4}$, and $X_{2\text{-}4}$, are cost criterion (the minimum amount of this criterion is desirable) and others are benefit criteria. This kind of classification is important for VIKOR analysis.

Decision-making team has followed every step of this project for this selection. They accepted the criteria list for evaluation of alternatives, which were derived from the literature survey. Also, they developed the problem structure (see Fig. 2).

For receiving general agreement in every step of this project, Delphi method was used. Delphi is a very famous method for receiving general agreement in complicated decision-making situations. Therefore, after a numerous discussions, a project team identified criteria for evaluation and they constructed problem structure. Then the project team accepted the criteria list that was explored from the literature study (see Table 1). There was a general consensus about this criteria list. As mentioned before, in this paper SWARA was used for calculating criteria weights.

In this section, the authors focus on obtained numerical results. In the first part, SWARA results will be discussed. As mentioned before, after determining all selection criteria and supplier alternatives, SWARA method was used to tackle the ambiguities involved in the process of the linguistic assessment of the criteria and alternatives. Like other similar methods (e.g. AHP and ANP), SWARA uses expert ideas or thoughts but experts can participate without difficulty in this method. Information about experts is shown in Table 2. Table 3 shows criteria weights and the decision matrix that is filled by experts. Also, Table 3 indicates the results of criteria weights for all assessment criteria, criteria and sub-criteria. The weight of each criterion is shown in the fifth column. The last column of Table 3 provides the evaluations of each alternative by experts that are used to calculate the rank of each alternative. Table 3 is used as an input, which is applied by VIKOR method. The aim of using VIKOR method is selecting the best supplier. After discussing SWARA results, in this section, the authors ranked suppliers based on VIKOR. Equations in VIKOR section were used for calculations in VIKOR method.

The authors had four alternatives in this paper and there were four potential suppliers as alternatives for evaluation. The alternatives were denoted as A_1, A_2, A_3, and A_4. Five decision-making experts evaluated each alternative giving a score. After creating the decision matrix, the normalized value was calculated and other steps based on VIKOR steps were followed (Opricovic 1998; Opricovic, Tzeng 2002, 2004).

According to Table 4, which shows ultimate results of VIKOR methodology Alternative 3 (supplier 3) is the best option for this problem. Based on this Table, this supplier can work and satisfy company's needs in an agile environment. Also, the proposed hybrid model provides a systemically analytic model for supplier selection in an agile environment.

Table 2. The characteristics of the five decision-making experts

		Gender	Age	Education Level	Experience (years)	Job title	Job responsibility
Decision-making expert	D1	Male	53	B Sc in management	> 30	Manager of the company (CEO)	In charge of the most important decisions of the company.
	D2	Male	50	M Sc in business administration	> 25	Supply chain manager	Managing the engineering team, supply chain, suppliers and new projects.
	D3	Female	49	M Sc in business administration	> 21	Operations manager	Managing, designing, and controlling the process of production and redesigning business operations in the production of goods and/or services.
	D4	Male	45	B Sc in industrial engineering	> 18	Production planning and material handling manager	Managing product lines, buying new materials and inventory planning.
	D5	Female	47	Ph D of philosophy's industrial engineering	> 14	Marketing manager	Responsible for R&D, marketing research and pricing decisions.

Table 3. Calculation results by applying SWARA and VIKOR methods

Criterion	Criteria weights based on SWARA				Decision matrix on VIKOR			
	Comparative importance of average value s_j	Coefficient $k_j = s_j + 1$	Recalculated weight $w_j = \frac{x_{j-1}}{k_j}$	Weight $q_j = \frac{w_j}{\sum w_j}$	A_1	A_2	A_3	A_4
X_1	0.28	1.28	0.781	0.272				
$X_{1\text{-}1}$		1	1	0.406				
$X_{1\text{-}3}$	0.25	1.25	0.8	0.326				
$X_{1\text{-}2}$	0.21	1.21	0.662	0.268				
$X_{1\text{-}1\text{-}1}$	0.13	1.13	0.884	0.270	9	5	4	8
$X_{1\text{-}1\text{-}2}$	0.16	1.16	0.645	0.196	4	8	9	6
$X_{1\text{-}1\text{-}3}$	0.18	1.18	0.749	0.228	4	4	6	3
$X_{1\text{-}1\text{-}4}$		1	1	0.306	8	3	5	3
$X_{1\text{-}2\text{-}1}$		1	1	0.545	9	3	4	6
$X_{1\text{-}2\text{-}2}$	0.20	1.20	0.833	0.455	6	9	8	9
$X_{1\text{-}3\text{-}1}$	0.26	1.26	0.793	0.317	5	6	7	8
$X_{1\text{-}3\text{-}2}$		1	1	0.400	9	6	3	4
$X_{1\text{-}3\text{-}3}$	0.12	1.12	0.708	0.283	4	8	8	5
X_2	0.32	1.32	0.591	0.207				
$X_{2\text{-}1}$	0.39	1.39	0.566	0.241	4	6	5	8
$X_{2\text{-}2}$		1	1	0.424				
$X_{2\text{-}2\text{-}1}$	0.21	1.21	0.751	0.284	8	5	3	4
$X_{2\text{-}2\text{-}2}$	0.1	1.1	0.909	0.341	2	4	3	6
$X_{2\text{-}2\text{-}3}$		1	1	0.375	4	3	3	6
$X_{2\text{-}3}$	0.27	1.27	0.787	0.335	6	4	3	4
X_3	0.20	1.20	0.492	0.171				
$X_{3\text{-}1}$		1	1	0.294	3	8	4	9
$X_{3\text{-}2}$	0.26	1.26	0.384	0.113	4	5	3	8
$X_{3\text{-}3}$	0.42	1.42	0.484	0.143				
$X_{3\text{-}3\text{-}1}$		1	1	0.568	4	9	6	5
$X_{3\text{-}3\text{-}2}$	0.31	1.31	0.763	0.432	6	5	8	4
$X_{3\text{-}4}$	0.18	1.18	0.847	0.248	9	6	8	4
$X_{3\text{-}5}$	0.23	1.23	0.688	0.202	6	4	4	7
X_4		1	1	0.350				
$X_{4\text{-}1}$	0.19	1.19	0.478	0.136	5	4	8	4
$X_{4\text{-}2}$	0.30	1.3	0.569	0.169	8	6	9	7
$X_{4\text{-}3}$	0.35	1.35	0.740	0.211	3	4	5	3
$X_{4\text{-}4}$	0.16	1.16	0.326	0.093	5	6	7	4
$X_{4\text{-}5}$		1	1	0.286	6	7	8	3
$X_{4\text{-}6}$	0.26	1.26	0.379	0.108	9	4	4	9

Table 4. Ultimate results and ranking of the alternatives

Alternatives	s_i	k_j	w_j	q_j	Ranking
A_1	0.541	0.074	0.5	0.713	3
A_2	0.496	0.058	0.5	0.472	2
A_3	0.350	0.042	0.5	0	1
A_4	0.569	0.100	0.5	1	4

Conclusion and future research directions

In the current era, many businesses have been forced to form a dynamic network of companies, namely agile supply chain, and outsourcing has also increased to help businesses concentrate on frequent market changes. In this regard, supply partner selection process becomes more crucial in today's highly competitive and global environment. The uncertainty and ambiguity of supplier selection process is the main reason to suppose an effective supply partner selection to achieve the successful operation of an ASC. To do so, in this paper, a hybrid MADM methodology with three phases based on integrating two MADM methods for selecting the most suitable supplier, was proposed. According to the results of this study, DMs were faced with critical factors that were found to influence an organization's decisions about evaluating and selecting a new supplier. According to the results, the case study is presented. Specifically, this study provides a valuable view that DMs should be selected as a decision-making team. In addition, SWARA method was used as a decision-making tool for extracting weights of criteria, which VIKOR needed. Therefore, VIKOR used SWARA result weights as input weights. Therefore, another significant contribution to this study is the proposed SWARA–VIKOR integrated approach. In general, the findings of this study have contributed towards providing important and advanced knowledge by various criteria and a simple, efficient method, with which managers of a company or decision-makers can increase their ability to choose an appropriate supplier. As a result of the study, the authors found that the proposed approach is practical for ranking supplier alternatives with respect to multiple conflicting criteria in an agile environment.

This study results show that decision criteria significantly influence on the choice of supplier selection. However, in this paper the most important criteria were selected based on the in-depth literature survey; another study could design a new structure with other criteria, sub-criteria and assessing alternatives with a new structure.

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