Appraisal the Key Factors of SCQM using a Combined Approach of SWARA-FISM

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***Abstract*— Researchers in recent years have introduced supply chain quality management as a new concept and use it considered as the last step in the move toward "total quality management" whereby company will be able to increase their quality and competitive advantage by efficiently and effectively integrate of the concepts of "Total Quality Management (TQM)" and "supply chain management (SCM)". In order to achieve this goal in the ABZARSAZI Industry, the first step in the implementation of supply chain quality management, is identifying the key success factors of quality management at the supply chain level; because the failure of this project seems imminent if the chain members do not agree on these factors. For this purpose, in this paper presented a conceptual model of supply chain quality management after the extensive review of the literature and identify the factors that affecting SCQM. Then, given the importance and sensitivity of each factors of proposed model to implement in the ABZARSAZI industry, by using SWARA (Stepwise weight assessment ratio analysis) technique, the final weight of was calculated and ranked in order of importance. The final result of SWARA technique and expert opinions in assessing the factors of SCQM systems in the industry showed that Quality Strategies in Supply Chain were detected in the first rank as the most important factor, and Process Approach was detected in the lowest rank. In following, the relationship and sequence of factors were determined with Fuzzy Interpretive Structural Modelling (FISM). The final result of FISM approach showed that the factors are levelled in five levels. So that "Supply Chain Quality Information Systems" and "Quality Strategies in Supply Chain" placed in the first level. Such "Process Approach" placed in the fifth level. With regard to the proposed model and taken prioritize, an action plan was provided for successful implementation SCQM in the ABZARSAZI industry.**

Keywords*:* TQM, SCM, SCQM, SWARA, FISM.

1. Introduction

A supply chain is one of the most integral parts of new business management in the design of services from suppliers to customer [1-3].
Recent studies on performance in supply chain management have indicated the need to deepen the understanding of the integration of quality management [4].
In contemporary supply chain management, the performance of potential suppliers is evaluated against multiple criteria rather than considering a single factor [5].
Supply chain management (SCM) can be considered as a key component of competitive strategy to enhance organizational productivity, performance and profitability [6].
While the importance of quality management is universally recognized, academic researchers need a more focused approach in evaluating quality management issues within the internal and external supply chain contexts [7].
SCQM is defined as "The formal coordination and integration of business processes involving all partner organizations in the supply channel to measure, analyze and continually improve products, services, and processes to create value and achieve the satisfaction of intermediate and final customers in the marketplace [8].
ABZARSAZI Industries in Iran, produces metal components that tries to improve its quality, safety and occupational hygiene performance constantly by establishing quality management systems, safety and occupational hygiene based on ISO9001:2008 and OHSAS18001:2007 for achieving its strategic aims. At present, having efficient human resource and equipped and advanced shop floors and also various processes of production such as machining, thermal operations, forging, founding, die making, etc. this industry is one of pioneer component maker companies in the country [9].
In this paper, according to the literature review, first we will identify the key factors of SCQM in the industry, and next the SWARA technique is used for weighting and ranking the factors. Finally the relationships between factors were

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structured by using Fuzzy Interpretive Structural Modelling (FISM).

Examining these relationships is very important because it allows us to deeply understand how SCQM practices impact on performance. Then this research also expects to offer the useful guidance for measuring and implementing SCQM practices as well as facilitate further researches in this field [10].

The rest of this paper is organized as follows: In Section 2 the factors are identified with Literature review; Section 3 gives a review of used technique (SWARA, FISM); In Section 4, Findings of Research is presented, finally section 5 is the Conclusion and Recommendations of this paper.

2. Literature Review and Conceptual Model of Research

Ref. [11] by a field study in Taiwan investigated influential variables in supply chain effectiveness increase in a quality-based environment. Fourteen aspects of SCQM by Ref. [11] has developed in which includes corrected version of eight critical factors provided by quality management by Ref. [12]. These factors include leadership of senior management, training, product design, supplier quality management, process management, quality data report and relationship with staffs. Ref. [11] introduced four new quality factors which include customer relationship, benchmarking, supplier selection and supplier communion. Also three additional change factors which originated from information technology were introduced. Information technology, IT-based operation process, IT-based organization integrity.

Ref. [13] stressed that collaborative communications with suppliers should develop instead of undesirable to ensure suppliers meet customers final needs.

Ref. [14] in their study sought to analyse the issues related to the quality of an organization in its supply chain and to do this, they examined the quality of supply chain management in US manufacturing companies. The results of this study showed that while companies introduce their main customers in quality initiatives but do not interfere with the main suppliers. While the quality of the deliveries components to the customers is directly related to the quality of the materials and components received from the suppliers, and the companies' effort more in improving the quality of their suppliers.

Ref. [15] examined the relationship between first, second, and third-tier suppliers in the automotive industry and the relationship between ensuring quality and providing returns in the supply chain.

Ref. [16] presented a causal model to examine the effect of two important activities of quality management (focusing on customers and quality management of suppliers) and other activities and their prior and mediator variables on "quality performance" and "financial and market performance" of the company. They showed that the two activities of "quality management of supplier" and "customer focus" are two important activities of quality management that are specifically focused on the domain of the supply chain management and therefore suggested that the managers to properly manage the quality, they should develop cooperative activities and interconnections at the supply chain level and integrate upstream and downstream quality improvement processes.

Ref. [17] proposed a strategic framework for implementation of supply chain quality management. In their research, they pursued four goals.

- Developing a Conceptual Framework for the Implementation of Supply Chain Quality Management
- Identifying potential gaps in the implementation of SCQM among supply chain members
- Identification of quality drivers in the supply chain
- Understanding the differences between the perceptions of high level managers and middle managers in implementing supply chain quality management.

Ref. [4] investigated the relationship between supply chain quality management practices, as well as the direct and indirect effects of these practices on firm performance. A conceptual model was developed and tested through path analysis using the cross-section data collected from automotive industry in Iran. The findings support the relationship between supply chain quality management practices and the positive effect of these practices on organisational performance, suggesting that organisational performance could be enhanced through improved supply chain quality management.

Ref. [18] also looked at the relationship between "supply chain quality assurance" programs and activities within the SCOR framework. In their research that the statistical society was the 232 Chinese companies holding the ISO 9000 certificate, they showed that if any of the five high-level SCOR model processes (planning, resource finding, production, delivery and return) effectively integrates with requirements and standards of ISO 9000 Quality Management System, the performance of supply chain quality will improve significantly across three performance criterion related to customers (reliability, accountability or flexibility and cost), which are considered by the SCOR model.

Ref. [19] presented a conceptual model for measuring the quality management of supply chain, which examined its status in Iran's automotive industry (Tondar 90 project of Iran Khodro).
Ahmadi in his dissertation explores the relationship between eight activities of total quality management (leadership, relationship management, strategic planning, human resource management, information management, customer focus and quality management process) with the supply chain results and designed and presented a causal model [19].
Ref. [20] report the results of a comparative study of quality tools and methods adoption by operations and supply chain managers. A survey was administered to both types of managers in the Western United States. They found that operations managers tend to manage supply chains through procedural methods such as ISO 9000 and supplier evaluation. Such, they found that both types of managers adopted on the job training, data analysis, supply chain management, customer relationship management, project management and surveys. This paper represents another step in defining the field of supply chain quality management.
Ref. [21] have referred to leadership as an important factor for focusing on the creation and maintenance of the corporation's internal environment. As individuals are fully involved in increasing the organization's quality objectives. Further attention to leadership in the organization will also lead to the survival of supply chains and management and performance improvement.
Ref. [22] have reported intensive studies based on the work carried out by various researchers in the area of supply chain management. Further, an attempt has also been made to identify conceptual interlinking between Supply chain management and Quality management through literature review.
Ref. [23] propose a quality-oriented approach model is proposed to aid the co-ordination and decision-making process and numerical examples illustrate the applicability of the proposed model and its approach to such design that encourages all partners to grow in the business process. The result is ensured dispatching, distribution and delivery of the right product at the right time. A mathematical model is proposed to aid the co-ordination and decision-making process and numerical examples illustrate the applicability of the proposed model and its approach.
Ref. [24] refer to quality of production / service and quality culture as two key principles of quality management (QM). They believe that these two principles are correlated with improving organizational performance. Quality of production / service is the expectation of the customer in the quality of the product / service received. In order to meet these expectations, companies need to design and establish financial policies, marketing strategies and products. It is also essential to establish quality assurance measures and follow up them. The quality culture involves participatory ideas, values, attitudes, institutions, and behavioural patterns of members of a community or organization. They also mention procurement, internal logistics, and distribution as the three main operations of Supply Chain Management (SCM). The procurement process is the main function of describing activities and processes for acquiring goods and services so that it enables the implementation of all processes in the chain. Therefore, the procurement agent includes all the activities involved in establishing basic needs, resource findings such as market research, seller assessment, calls and negotiations. Internal logistics is involved in the value added of the supply chain, and it is essential in conversion of the raw materials to the final products and operational function of the company. The distribution includes a wide range of activities related to the efficient and effective circulation of materials from the chain resource to the point of use and consumption. Finally Ref. [24] described the six operational dimensions of quality management and supply chain management as follows: strategic management and planning, employee / stakeholder involvement and engagement, information, integration, and mutually beneficial communication between suppliers, leadership and Continuous improvement and innovation.
Ref. [25] analysed the effect of product structure on the decision to control the quality of the supply chain.
Ref. [6] evaluated the SCQM of Gas Industry in Iran with path analysis.
Based on the literature and interviews with industry managers, the key factors of SCQM are defined as bellow: Customer focus or Oriented Customer (F1); Suppliers' Quality Management (F2); Supply Chain Quality Leadership (F3); Quality Strategies in Supply Chain (F4); Process Approach (F5); and Supply Chain Quality Information Systems (F6); Development of Human Resources in Supply Chain (F7). The figure 1 shows key factors of SCQM as a conceptual model.

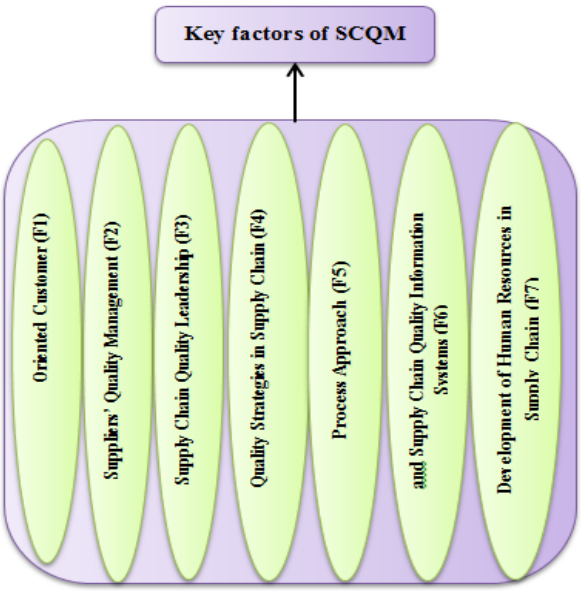

Figure 1: the conceptual model of research [6]

The SWARA is initially used for calculating the weight of each factor. The FISM is adopted for analysing, explanation and levelling the relationship between factors.

3. A review of used techniques

3.1. The SWARA

In order to prioritize the identified key barriers, SWARA technique is used. SWARA is one of the new methods of MCDM which was used in 2010 to develop analysis of the differences between the criteria. In SWARA, each expert ranks the criteria at first. The most important criterion is scored one and the least important one receives low score. Finally, the criteria are prioritized according to average values of the relative importance. In this method, the expert assesses the calculated weights. In addition, each expert specifies the importance of each criterion according to tacit knowledge, information and experience. Then according to the average value of the group's ranks obtained by experts, the weight of each criterion is determined [26]. Therefore, in this study, the views of 20 Iranian Industries experts were used. The weight of each criterion indicates its importance. Measuring of weight is an important topic in many issues of decision-making. SWARA is one of the weighting methods in which professionals play an important role in the calculation of their weight and final assessment. Figure 2 shows the technique executive steps [27-29].

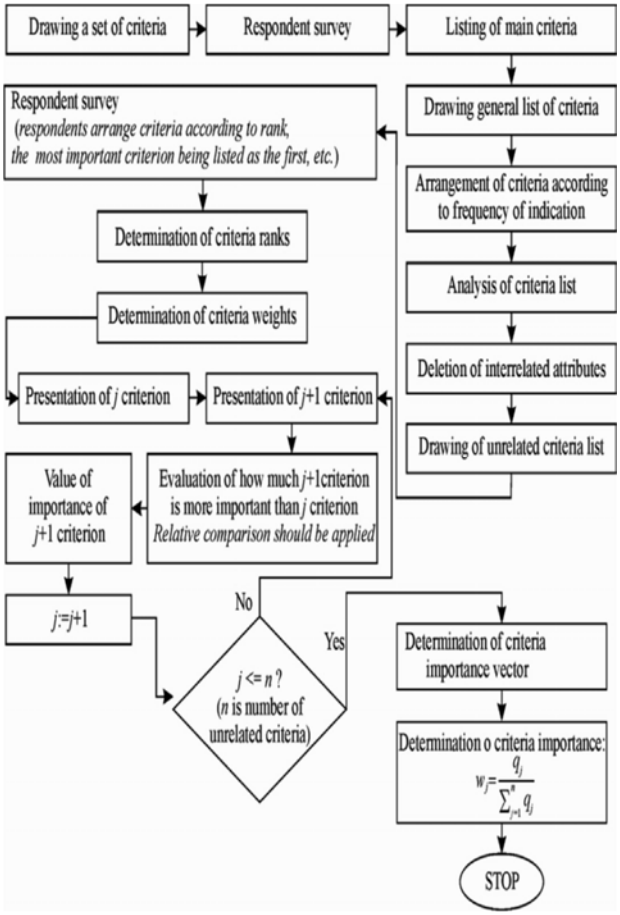

Figure 2: The technique executive [27-29]

3.2. The ISM

ISM is based on group judgment on the extent and nature of relationship among the elements. The interpretations of the group have been used to draw the overall structure from the complex set of elements. The final structure has been portrayed in a digraph [30]. ISM is an interactive learning process [31]. In this, a set of different directly and indirectly related elements are structured into a comprehensive systemic model [30], [32]. The model so formed portrays the structure of a complex issue, a system of a field of study, in a carefully designed pattern employing graphics as well as words [33]. ISM methodology helps to understand the order and direction on the complexity of relationships among elements of the case problem [30] structural flexibility in the SCs, thereby affecting their productivity. The direct and indirect relationships among various elements depict the situation more accurately than the case when an individual factor is considered in a stand-alone mode. ISM develops insights into the collective understanding of these relationships. ISM is interpretive as the judgment of the group of experts decides whether and how the variables are related. It is structural, as on the basis of the

relationship an overall structure is extracted from a complex set of variables. It is a modelling technique as the overall structure and specific relationships are portrayed in a graphical model. It is primarily intended as a group learning process but can also be used individually [34].

3.3. The Fuzzy ISM

Fuzzy ISM gives a pictorial representation of the interrelationships between the elements in the cluster. Instead of representing the relationships by 0 and 1, clear quantified relationships always give a better value addition. A picture is thousand times worthy than an enumeration. In this regard, a three dimensional view of Fuzzy ISM is plotted using the software MATLAB. The Fuzzy ISM thus is plotted and is shown in Figure 3.

X and Y axes indicate the elements. Their interrelationships in terms of intensity on a Likert scale of 0–10 are shown on the Z axis. The interrelationships are expressed by the term intensity in the Figure 2. The elements having no interrelationship have the intensity values of 0 (zero) [35].

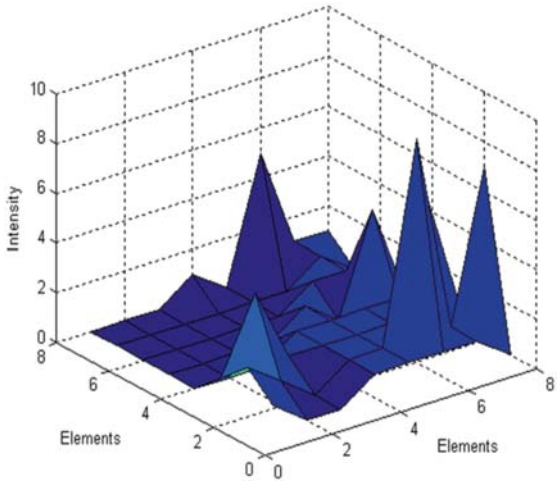

Figure 3: Fuzzy ISM [35]

Steps of this approach are summarized as below:[36-38].

Step 1: Pair comparison of variables (Barriers) using of variables as table 1:

Table 1: Definition of variables in FISM

Triangular number	Verbal variable	Symbol
(0.75,1,1)	Very strong	AR
(0.5,0.75,1)	Strong	SR
(0.25,0.5,0.75)	Relatively	FR
(0.0,0.25,0.5)	Weak	LR
(0,0,0.25)	Very weak	UN

Step 2: Gathering of expert's opinions using geometric mean method [38].

Step 3: Defuzzication of fuzzy numbers using of centroid method as below:

$$\pi_{ij} = \frac{l_i + m_i + u_i}{3}$$

Step 4: Formatting of initial reachability matrix using of relation as below:

if $\pi_{ij} \geq t \rightarrow \pi_{ij} = 1$

if $\pi_{ij} < t \rightarrow \pi_{ij} = 0$

Step 5: Formatting of final reachability matrix using of relation as below:

M=D+I

$M^{*}=M^{k}=M^{K+1}$ k>1

Step 6: Drawing of ISM diagram

Step 7: MICMAC analysis

4. Findings of Research

In this section, first we calculate the weight of barriers as following:

4.1. Weighing and Ranking the key factors of SCQM with SWARA

After the literature review of research and interview with experts, 7 factors of SCQM in ABZARSAZI industry were identified as table 2:

Table 2: The key factors of SCQM implementation

Symptom	Key Factors
F1	Customer Focus or Oriented Customer
F2	Suppliers' Quality Management
F3	Supply Chain Quality Leadership
F4	Quality Strategies in Supply Chain
F5	Process Approach
F6	Supply Chain Quality Information Systems
F7	Development of Human Resources in Supply Chain

Then, these factors were studied using SWARA technique. SWARA technique is based on expert's opinions, and it is a judgment method. In this research, we have used from 20 experts as table 3:

Table 3: Information of experts

Group	Classification	Number
Record of service	Manager	1
	Quality & Engineering	12
	Programming and control	7
Education level	Licentiate	6
	Master	10
	Doctoral	4
Sexuality	Male	15
	Female	5

For doing so, the opinions of 20 experts on key factors of SCQM implementation were identified and the factors initial weight was extracted. In fact, the experts were asked to rank each factor individually, and finally to calculate the relative importance of these factors, count the number of priorities of each factor according to experts' viewpoints.

For example, the first factor was placed two times in rank one; three times in rank two; six times in rank three; five times in rank 4; two times in rank

5; one time in rank 6; and one time in rank 7. After prioritizing key factors by the experts, to calculate the weight of each barrier, the number of priorities for each barrier was multiplied by the difference score of the highest score and relevant score.
Table 4 summarizes final calculation of the weight and importance of each of the factors using SWARA, so that factors can be ranked according to the last column weights.
So, table 4 shows that the forth factor (Quality Strategies in Supply Chain) is the most important and the fifth factor (Process Approach) is the least important in between the factors.

Table 4: The weight and importance of each of the factor

Factors	Sj	Kj =Sj+1	Wj	Qj	Rank
F4	-	1	1	0.215	1
F6	0.132	1.132	0.884	0.19	2
F2	0.15	1.15	0.769	0.164	3
F1	0.175	1.175	0.655	0.141	4
F3	0.212	1.212	0.541	0.116	5
F7	0.206	1.206	0.449	0.096	6
F5	0.232	1.232	0.365	0.078	7

4.2. Implementation the Fuzzy ISM and Levelling of Factors

Interpretive structural modelling is an interactional learning process which a set of different and related elements are organized in a systematic model in it. ISM not only provides a vision on the relationship among the different elements of a system, but also suggests a structure according to the importance and influence of the elements on each other and it also offers a visual representation [39].
In this research, in order to level partition and determining the relationship among the factors of SCQM implementation, after reviewing the related literature and the experts' idea's, seven main factors were identified.
According to the obtained matrix and mentioned rules, the initial reachability matrix was calculated and the final reachability matrix was obtained after multiplying the initial reachability matrix by power of six shown in table 5.

Table 5: The final reachability matrix

Driving power	C7	C6	C5	C4	C3	C2	C1	Row
5	0	1	1	1	0	1	1	C1
5	1	1	1	1	0	1	0	C2
6	0	1	1	1	1	1	1	C3
3	0	1	0	1	0	0	1	C4
6	1	1	1	0	1	1	1	C5
6	1	1	1	1	1	1	0	C6
5	1	1	0	1	0	1	1	C7
	4	7	5	6	3	6	5	Dependence power

Level Partition of factors is done using final reachability matrix shown in the table 6:

Table 6: Level Partition of factors

Factor	Intersection set	Antecedent set	Reachability	Level
1	1-5	1-3-5-7	1-5	3
2	2-5-7	1-2-3-5-7	2-5-7	2
3	3-5	3-5	3-5	4
4	1-4-6	1-2-3-4-6-7	1-4-6	1
5	3-5-7	3-5	3-5	5
6	2-3-4-5-6-7	1-2-3-4-5-6-7	2-3-4-5-6-7	1
7	7	5-7	7	4

Figure 4 shows the research ISM obtained after determining the grade of all Factors. According to the figure 4, and also removing extending relation and final diagram, the "Supply Chain Quality Information Systems" and "Quality Strategies in Supply Chain" are placed in the first level, the "Suppliers' Quality Management" in the second level, "Customer Focus" in the third level, "Development of Human Resources in Supply", "Supply Chain Quality Leadership" in the fourth level, and finally the "Process Approach" in the fifth level.

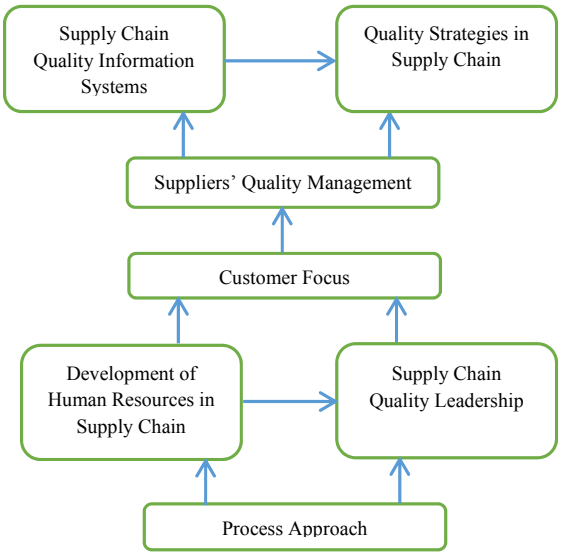

Figure 4: FISM Model

As it is seen in the model, the "Supply Chain Quality Information Systems" and "Quality Strategies in Supply Chain" as the first level factors are influenced and dominated by others. The "Process Approach" has the highest effect and it is located in the fifth level of the proposed model. The factors of second level, third level and the fourth level are as Intermediate levels. The factors of third level and fourth level affect from the fourth level factors, and effect on the second level factors. The fourth level factors affect from the fifth level factors, and effect on the third level factors
Such the second level factors effect on the first level factors and affects from the third level factors.

5. Conclusion and Recommendations

Competition of today's organizations in the supply chain has increased by growing the level of the globalization competitiveness, and is included all chain members and external organizations. Inter organizational perspectives about quality operations have some limitations; therefore, manufacturers should pay attention to supply chain quality management (SCQM) as an interagency approach to quality. SCQM will help the manufacturing companies to better satisfy their customers' needs in a competitive market. For this purpose, in this study, after identification the structure of supply chain and supply chain quality management practices through comprehensive review of the literature, was presented a comprehensive definition about concept of supply chain quality management (SCQM) and finally presented a conceptual framework by studying the dimensions of SCQM that have seven factors.

In the following the factors were ranked using SWARA method.

Finally, communication and sequencing of these factors were determined by FISM. In this regard, after the assessment, these factors were placed in five levels.

Thus, the proposed model can help the ABZARSAZI industry in the implementation of quality management in their supply chain for achieve to competitive advantages and satisfying the customer needs.

Also, it is recommended to path analysis (the second order factor analysis) and structural equation modelling by software SPLS in the future research for confirming and fitness of the relations among Factors in the proposed FISM. In addition to, the fuzzy DEMATEL is in order to determining the intensity between of factors and selection the most important according to the effecting & affecting amount. Such, we can use FANP for ranking of factors and compare the results with SWARA.

Such, This proposed decision making model can be used in other areas of managerial decision making such as project selection, location selection and technology selection in supply chain.

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