A Fuzzy AHP Approach for Ranking the Application Barriers of Green SCM (Case study: Abzarsazi Industries of Iran)

Ahmad Jafarnejad, Hossein Jannatifar, Mehdi Ajalli

Abstract— Supply chain management (SCM) issues have been popularly discussed in recent years. SCM represents the integration of key business processes among industry partners to add value for the end customers. GSCM was starting debated since the quality revolution of the 1980s and supply chain revolution of the 1990s. Generally, GSCM is understood to involve screening suppliers based on their environmental performance and doing business only with those that meet certain environmental regulations or standards.

This paper first identifies the Implementation Barriers of GSCM through literature review and then uses the Fuzzy AHP approach for ranking the barriers in Abzarsazi Industries of Iran.FAHP is a new multi-criteria evaluation method evolved from Saaty's AHP. So, this paper aimed to find out and rank the key factors and barriers that affect success in GSCM using fuzzy AHP approach, and give an evaluation method for GSCM in order to help researches and managers to determine the drawbacks and opportunities.

***Index Terms*— SCM, GSCM (Green Supply Chain Management), Fuzzy set theory, Fuzzy AHP, Barriers.**

I. INTRODUCTION

Supply chain management (SCM) has been brought into academic research since the early 1980s, covering a range of control and planning applications relating to material selection, production, transportation, distribution etc., as well as the potential collaboration among manufacturers, retailers and customers (Blanchard, 2007, p. 8; Harrison & Hoek, 2008, p. 6; Hines, 2004, p. 70; Oliver & Webber, 1982). A wide variety of research papers that employ non-cooperative game theory to model interaction between players. For an excellent survey and state of art techniques, we refer you to Cachon and Netessine (2004). A supply chain is one of the most integral parts of new business management in the design of services from suppliers to customer (Five Winds International, 1999; Christopher, 1998). In supply chains with multiple vendors, manufacturers, distributors and retailers performance measurement is difficult due to the challenges involved in the attribution of performance results to any other element of the chain. Measuring performance within organizations raises challenges in inter-organizational and environmental performance measurement leading some organizational studies to conclude their inability to measure performance. Performance measurement in supply chains is made more difficult for additional reasons, especially since the analysis consists of numerous tiers within the chain itself (Jalali Naini et al., 2011).

In recent years, green supply chain management (GSCM) initiatives have gained considerable prominence. However, how much value it brings to organizations is still being investigated. Kogg (2003) used the definition of GSCM given by Zsidisin et al., (2001): “the set of supply chain management policies held, actions taken and relationships formed in response to concerns related to the natural environment with regard to the design, acquisition, production, distribution, use, re-use and disposal of the firm’s goods and services”. Srivastava (2007) defined GSCM as “integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final products to the consumers, and end-of-life management of the product after its useful life”. Generally, GSCM is understood to involve screening suppliers based on their environmental performance and doing business only with those that meet certain environmental regulations or standards (Rao, 2002). Supplier selection either in GSCM or sustainable supply chain management (SSCM) has been identified as significant in making purchasing decisions (Hu et al., 2010). Simultaneously in the operational process of supply chain management, thus contributing to the initiative of green-supply chain management (GSCM).

In this research, in first we identified the Implementation barriers of GSCM in Abzarsazi Industries of Iran and then have used the Fuzzy AHP approach for ranking the barriers. The AHP was developed in the 1980s by Saaty. It is a systematic decision making method which includes both qualitative and quantitative techniques. It is being widely used in many fields for a long time. But one of the critical steps of AHP method is to set up the comparison matrixes. When the number of criteria’s (or alternatives) in the hierarchy increases, more comparisons between criteria’s (or alternatives) need to be made. This could easily cause confusion due to the excess of questions and hence the efficiency of the model. So a consistency check is required for the pair-wise comparison matrix. Therefore, whether the setting of the comparison matrix is scientific affects the correctness of AHP directly. When the comparison matrices are not consistent, we should adjust the elements in the matrixes and carry out a consistency test until they are consistent. Traditional AHP requires exact or crisp judgments (numbers). However, due to the complexity and uncertainty

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involved in real world decision problems, decision makers might be more reluctant to provide crisp judgments than fuzzy ones. In this paper, we will use a fuzzy AHP in which substitute membership scales for Saaty's 1-9scales to reduce adjusting times needed. The reminder of this paper is organized as follows: Section 2, gives a review of GSCM, in Section 3, Implementation Barriers of GSCM is discussed, Section 4 presents a brief review of AHP and Fuzzy AHP, Section 5, gives evaluation the application barriers of GSCM and then rank the barriers; Finally in section 6, is the conclusion of this paper.

II. GSCM (Green Supply Chain Management)

With global business developing rapidly, the increasing demand for the consumption of commercial products has greatly accelerated the depletion of resources and contributed environmental pollution.

GSCM is defined to be the addition of green issues into supply chain management (Hervani et al., 2005). In addition, Zhu et al., (2004) state that GSCM supply chain involves from suppliers to manufacturers, customers and reverse logistics throughout the so called closed-loop supply chain. Hervani et al. (2005) indicate there are various activities involving GSCM such as reuse, remanufacturing, and recycling which are embedded in green design, green procurement practices, total quality environmental management, environmentally friendly packaging, transportation, and various product end-of-life practices. Green supply chain management (GSCM) is one of the corporate environmental management that had been recognized and applied by among manufacturing companies. Zhu et al., (2004) defined GSCM has a ranged from green purchasing to integrated supply chains starting from suppliers, to manufacturer, to customer and reverse logistics. Green supply chain management (GSCM) has emerged as a response to the challenge of how to improve long term economic profits and environmental performance (Sheu et al., 2005). GSCM can be defined as a series of regulations and interventions in the supply chain achieved by attempting to minimize the environmental impact from the suppliers to the end users (Basu et al., 2008, p. 245). It is also claimed to be a “win-win” strategy, through which economic benefits can be increased by reducing environmental impact (Zhu et al., 2004; Zhu et al., 2008).

3.Implementation Barriers of GSCM

Based on the previous literatures review, we focus on four main aspects including Organization Management, Organizational Culture, Organizational Structure and Rules and Guidelines (See Jalalifar et al., 2013). From these main aspects, 18 Effective Barriers in GSCM implementation are maintained. The classification of those main Criteria and their Sub-Criteria are shown in Table 1.

Table1: Implementation Barriers of GSCM (Jalalifar et al., 2013)

Criteria	Sub-Criteria	Reference
Organization Management	Instability of the senior management	Sarkis (2009), Balasubramanian (2012), Ravi and Shankar, (2005), Yu & Hui , (2008)
	Lack of top management support	Helen and Neil (2012), Ravi and Shankar, (2005), Yu & Hui ,(2008)
	Lack of knowledge and experience of staff	Balasubramanian (2012), Ravi and Shankar, (2005), Hall (2006)
	Employee dissatisfaction	Sarkis (2009), Balasubramanian (2012), Ravi and Shankar, (2005)
Organizational Culture	Weak Organizational Culture	Sarkis (2009), Balasubramanian (2012), Ravi and Shankar, (2005)
	Lack of attention in Green Innovation	Sarkis (2009), Balasubramanian (2012), Ravi and Shankar, (2005)
	Lack of resources	Sarkis (2009), Helen and Neil (2012), Ravi and Shankar, (2005)
	the lack of incentive legislation for the Green Supply Chain	Balasubramanian (2012), Ravi and Shankar, (2005), Hall (2006)
Organizational Structure	Uncertainty in the Supply Chain	Sarkis (2009), Balasubramanian (2012), Helen and Neil (2012)
	Lack of technical infrastructure	Sarkis (2009), Balasubramanian (2012), Ravi and Shankar, (2005)
	Lack of information needed	Sarkis (2009), Balasubramanian (2012), Ravi and Shankar, (2005)
	Lack of communication between members of the supply chain	Sarkis (2009), Balasubramanian (2012), Ravi and Shankar, (2005)
	attention to the short-term profit	Sarkis (2009), Balasubramanian (2012), Ravi and Shankar, (2005)
Rules and Guidelines	Lack of financial resources	Balasubramanian (2012), Ravi and Shankar, (2005)
	Lack of government support	Balasubramanian (2012), Ravi and

		Shankar, (2005), Sarkis (2009)
	Slow Return to capital after the implementation of green supply chain	Helen and Neil (2012), Ravi and Shankar, (2005)
	Lack of supply chain integration	Balasubramanian (2012), Ravi and Shankar, (2005), Hall (2006)
	Lack of appropriate strategies for green supply chain vision and mission	Balasubramanian (2012), Helen and Neil (2012), Sarkis (2009), Hall (2006)

4. A brief review of AHP and Fuzzy AHP

4.1. AHP

Multi-criteria decision making deals with the problem of choosing the best alternative, that is, the one with the highest degree of satisfaction for all the relevant criteria or goals. In order to obtain the best alternative a ranking process is required. Extensively adopted in MCDM, the analytic hierarchy process (AHP) has successfully been applied to the ranking process of decision making problems. The main advantage of the AHP is its inherent ability to handle intangibles, which are present in any decision making process. Also, the AHP less cumbersome mathematical calculations and, it is more easily comprehended in comparison with other methods. Analytic hierarchy process (AHP) is developed by Saaty (1982, 1988, 1995) that is probably the best known and most widely used MCA approach. (Cathy et al. 2004). Also it has been extensively used as a multiple criteria decision-making (MCDM) tool or a weight estimation technique in many areas such as selection, evaluation, planning and development, decision making, forecasting, and so on (Vaidya et al., 2006).

AHP is a probably the most widely applied MCA for the evaluation of various transport projects related to organizational, technological, environmental and infrastructural decision subjects (see Ferreira, 2002; Tudela et al., 2006; Sharifi et al., 2006; Janic, 2003; Tzeng et al., 2005, and so on). AHP is especially advantageous with respect to its ability to decompose a complex problem into its constituent parts and its simplicity in use (Macharis et al., 2004; Dagdeviren, 2008; Konidari and Mavrakis, 2007). On the other hand, AHP is often criticized with respect to the complete aggregation of the criteria which might lead to important losses of information (e.g., in case where trade-offs between good and bad scores on criteria occur). Additionally, the amount of pair-wise comparisons for the evaluation of the alternatives in terms of their contribution to the criteria might become substantially high (Macharis et al., 2004).

Triantaphyllou et al. (1996) and Duran et al. (2007), summarized the following advantages for AHP: (1) it is the only known MCDM model that can mea-sure the consistency in the decision maker's judgments; (2) the AHP can also help decision makers to organize the critical aspects of a problem in a hierarchical structure, making the decision process easy to handle; (3) pair-wise comparisons in the AHP are often preferred by the decision makers, allowing them to derive weights of criteria and scores of alternatives from comparison matrices rather than quantify weights/scores directly; (4) AHP can be combined with well-known operation research techniques to handle more difficult problems; (5) AHP is easier to understand and can effectively handle both qualitative and quantitative data.

The AHP method is based on three principles: (1) construction of a hierarchy, (2) priority setting and (3) logical consistency (Macharis et al., 2004). First, a hierarchy is used to decompose the complex system into its constituent elements. A hierarchy has at least three levels: the overall objective or focus at the top, the (sub-) objectives (criteria) at the intermediate levels and the considered alternatives at the bottom (Macharis et al., 2004; Dagdeviren, 2008). Second, the relative priorities of each element in the hierarchy are determined by comparing all the elements of the lower level against the criteria, with which a causal relationship exists. The multiple pair-wise comparisons are based on a standardized comparison scale of 9 levels; see Table 2 (Saaty, 2008). The result of the pair-wise comparisons is summarized in the pair-wise comparison matrix Table 3, where its standard element $P_c(a_i, a_l)$ indicates the intensity of the preference of the row element (a_i) over the column element (al) in terms of their contribution to a specific criterion C. Lastly, the consistency of decision makers as well as the hierarchy can be evaluated by means of the consistency ratio (Wang and Yang, 2007). This procedure is explained in detail in Saaty (1988).

Table 2: The Saaty scale for pair-wise comparison (Saaty, 2008)

Intensity of importance	**Definition**
1	Equal importance
3	Moderate importance
5	Higher importance
7	Much higher importance
9	Complete dominance
2,4,6,8	Intermediate values
$\frac{1}{2}, \frac{1}{3}, \frac{3}{4}, \dots, \frac{1}{9}$	Reciprocals

Table 3: Pair-wise comparison of elements in AHP

C	a_1	...	a_l	...	
a_1	1				

...		[1]			
a_i			$P_c(a_i, a_l)$		
...				[1]	
a_n					1

Briefly, Implementation of this technique consists of five steps as follows: (Saaty, 1988).

1. Determining a Hierarchical Tree: AHP uses a multi-level hierarchical structure that comprises a goal, criteria (and sub criteria) and options.

2. Finding priority of the criteria: AHP uses a set of pair-wise comparisons to calculate the relative weights of importance of the criteria.

3. Scoring of options based on each criterion: in this stage like stage 2, pair-wise comparison of options in terms of each criterion carry outs. Then, the ratings are normalized and averaged.

4. Obtaining Consistency Ratio (CR): The important stage is to obtain a CR to measure how consistent the judgments have been relative to large samples of purely random judgments. It is noteworthy that consistency ratio should calculate for each of pair-wise comparisons. The CR should be ≤ 0.1. It means that, if the CR is much in excess of 0.1, the judgments are untrustworthy and the pair-wise comparison is valueless and it must be repeated.

5. Calculating the final score: Finally, the option scores are combined with the criterion weights to make a final score for each option.

Sometimes, there are two or more decision makers (DMs). So, geometric mean method should be used to aggregate individual judgments.

4.2. Fuzzy sets

When establishing a structural model, human judgments for deciding the relationship between systems (or subsystems) are usually given by crisp values. However, in many cases, crisp values are inadequate in the real world. Human judgments with preferences are often unclear and hard to estimate by exact numerical values has created the need for fuzzy logic. Moreover, a more sensible approach is to use linguistic assessments instead of numerical values, in which all assessments of criteria in the problem are evaluated by means of linguistic variables (Zadeh, 1965).

Zade (1965) as cited in Dehkordi (2012) introduced fuzzy sets to deal with problems which have a source of vagueness that has been utilized for incorporating imprecise data into decision framework. A fuzzy set $\tilde{A}$ can be defined mathematically by a membership function$\mu_{\tilde{A}}$,which assigns each element x in the universe of discourse$X$ a real number in the interval[0, 1].A triangular fuzzynumber $\tilde{A}$can be defined by a triplet (a, b, c) as illustrated in Figure1.

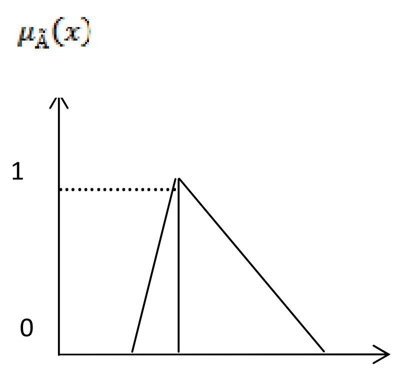

Figure 1: M-triangularU-Fuzzy number $\tilde{A}$

The membership function $\mu_{\tilde{A}}(x)$is defined as:

$$\mu_{\tilde{A}} \begin{cases} \frac{x-a}{b-a} & a \le x \le b \\ \frac{x-c}{b-c} & b \le x \le c \\ 0 & otherwise \end{cases} \quad (1)$$

Basic arithmetic operations on triangular fuzzy numbers$A_1 = a_1, b_1, c_1$, where$a_1 \le b_1 \le c_1$, and $A_2 = a_2, b_2, c_2$where$a_2 \le b_2 \le c_2$,can be shown as follows**:**

Addition: $A1 \oplus A2$=$(a_1 + a_2, b_1 + b_2, c_1 + c_2)$ (2)

Subtraction: $A1 \ominus A2 = (a_1 - c_2, b_1 - b_2, c_1 - a_2)$ (3)

Multiplication: if k is a scalar

$$k \otimes A_1 = \begin{cases} (ka_1, kb_1, kc_1), k > 0 \\ (kc_1, kb_1, ka_1), k < 0 \end{cases} \quad (4)$$

$A_1 \otimes A_2 \approx (a_1 a_2, b_1 b_2, c_1 c_2),\ if\ a_1 \geq 0, a_2 \geq 0$
(5)

Division: $A_1 \oslash A_2 \approx (\frac{a_1}{c_2}, \frac{b_1}{b_2}, \frac{c_1}{a_2})$, if $a_1 \geq 0, a_2 \geq 0$

Although multiplication and division operations on triangular fuzzy numbers do not necessarily yield a triangular fuzzy number, triangular fuzzy number approximations can be used for many practical applications. Triangular fuzzy numbers are appropriate for quantifying the vague information about most decision. The primary reason for using triangular fuzzy numbers can be stated as their intuitive and computational-efficient representation. A linguistic variable is defined as a variable whose values are not numbers, but words or sentences in natural or artificial language. The concept of a linguistic variable appears as a useful means for providing approximate characterization of phenomena that are too complex or ill-defined to be described in conventional quantitative terms (Dehkordi, 2012).

4.3. Fuzzy AHP

AHP is widely used for multi-criteria decision making and has successfully been applied to many practical problems (Saaty, 1980). In spite of its popularity, this method is often criticized for its inability to adequately handle the inherent uncertainty and imprecision associated with the mapping of the DM's perceptions to exact numbers. Traditional AHP requires exact or crisp judgments (numbers). However, due to the complexity and uncertainty involved in real world decision problems, decision makers might be more reluctant to provide crisp judgments than fuzzy ones. Furthermore, even when people use the same words, individual judgments of events are invariably subjective, and the interpretations that they attach to the same words may differ. Moreover, even if the meaning of a word is well-defined (e.g., the linguistic comparison labels in the standard AHP questionnaire responses), the boundary criterion that determines whether an object does or does not belong to the set defined by that word is often fuzzy or vague. This is why fuzzy numbers and fuzzy sets have been introduced to characterize linguistic variables. A linguistic variable is a variable whose values are not numbers but words or sentences from a natural or artificial language. Linguistic variables are used to represent the imprecise nature of human cognition when we try to translate people's opinions into spatial data. The preferences in AHP are essentially human judgments based on human perceptions (this is especially true for intangibles), so fuzzy approaches allow for a more accurate description of the decision-making process (M.-F. Chen et al. 2008). A number of methods have been developed to handle fuzzy AHP. Decision making expert systems are often complex and multifaceted. In recent years, tools for modeling decision making have improved significantly, and multi-criteria decision making (MCDM) models are widely considered to be very useful in resolving conflicts related to the decision making process. Since Bellman and Zadeh (1970) developed the theory of decision behavior in a fuzzy environment, various methods have been developed for handling multi-criteria decision making systems (Beynon, et al. 2001; Chen et al. 2005; Chen et al. 2010; Chen et al. 2009; Fu, 2008; Hua et al. 2008; Kahraman et al. 2009; Kwon et al. 2004; Kwon et al. 2007; Lin et al. 2007; Mikhailov, 2003; Tacker et al. 1991;Yager, 1991, 1992).

In the literature, several approaches to fuzzy AHP have been proposed by various authors. The first method was proposed by Van Laarhoven and et al. (1983). In this method, elements in the reciprocal matrix were expressed by triangular fuzzy numbers. In contrast, Buckley (1985) used trapezoidal numbers to determine fuzzy comparison ratios. He criticized Laarhoven and Pedrycz's method since linear equations do not always yield a unique solution, and this method is only valid for triangular fuzzy numbers. Bounder et al. (1989), pointed out an error in the method of Laarhoven and Pedrycz, and showed how it can be corrected. Mohanty and Singh (1994), introduced a procedure for solving an AHP problem in a fuzzy environment. (Ruoning et al. 1992), discussed the extensions of AHP to fuzzy environments and presented a procedure for constructing the fuzzy judgment matrix. Their subsequent paper, continues the discussion and goes further into the problem of extracting the fuzzy weights from the fuzzy judgment matrix by the logarithmic least squares method, which is one of the main ranking methods in AHP (Ruoning et al. 1996). Chang (1996), proposed a method that uses triangular fuzzy numbers for the pair-wise comparison scale of fuzzy AHP and extent analysis for the synthetic extent values of pair-wise comparisons. Gogus and Boucher (Gogus et al. 1997) presented some results and extensions of the use of fuzzy pair-wise comparisons in multi-criteria decision analysis. In another paper, Gogus et al. 1998 defined strong transitivity and weak monotonicity for fuzzy pair-wise comparison matrices. Deng (1999), presented a simple and straightforward fuzzy approach to qualitative multi-criteria analysis problems. Zhu et al. (1999), proved the basic theory of triangular fuzzy numbers and improved the criteria for comparing the sizes of triangular fuzzy numbers. Ruoning(2000), dealt with the question of estimating the weights of factors by least squares from a fuzzy judgment matrix. Mikhailov (2000) proposed a new Fuzzy Programming Method, based on a geometrical representation of the prioritization process. Csutoraet al. (2001), presented a new method of finding the fuzzy weights in fuzzy hierarchical analysis, which is the direct fuzzification of the kmax method. Buckley et al. (2001), presented a new method of finding the fuzzy weights. By applying the properties of goal programming (GP) to treat a fuzzy AHP problem, Yu (2001) incorporated an absolute term linearization technique and a fuzzy rating expression into a GP–AHP model for solving fuzzy AHP problems in group decision-making. Mikhailov(2003) proposed a new approach to deriving priorities from fuzzy pair-wise comparison judgments, based on an a-cuts decomposition of the fuzzy judgments into a series of interval comparisons. Eneaet al. (2004) presented an approach based upon a fuzzy extension of the AHP. This paper focuses on the constraints that have to be considered within fuzzy AHP in order to take into account all the available information. This study demonstrates that more certain and reliable results can be achieved by considering all the information derived from the constraints. Kulak et al. (2005) dealt with a multi-attribute transportation company selection for effective supply chain using both fuzzy multi-attribute axiomatic design and fuzzy AHP. Erensal et al. (2006) used the fuzzy AHP to analyze the links between competitive advantages, competitive priorities and competencies of a firm in the context of technology management. Göleçet al. (2007) presented a comparative study to establish complex fuzzy methodologies in evaluating the performance of a manufacturing system and showed that fuzzy AHP leads to the best result.

4.3. FUZZY AHP stepwise procedure

Fuzzy AHP uses fuzzy set theory to express the uncertain comparison judgments as a fuzzy numbers. The main steps of fuzzy AHP are as follows:

Step1: Structuring decision hierarchy, Similar to conventional AHP, the first step is to break down the complex decision making problem into a hierarchical structure.

Step2: Determination of Fuzzy Pair-wise Matrix as below:

	C_1	C_2	…	C_n
C_1	(1,1,1)	$(a_{12}^l, a_{12}^m, a_{12}^u)$	…	$(a_{1n}^l, a_{1n}^m, a_{1n}^u)$
C_2	$(a_{21}^l, a_{21}^m, a_{21}^u)$	(1,1,1)	…	$(a_{2n}^l, a_{2n}^m, a_{2n}^u)$
⋮			⋮	⋮
C_m	$(a_{m1}^l, a_{m1}^m, a_{m1}^u)$	$(a_{m2}^l, a_{m2}^m, a_{m2}^u)$	…	(1,1,1)

That: $(a_{ij}^l, a_{ij}^m, a_{ij}^u) = (\frac{1}{a_{ji}^l}, \frac{1}{a_{ji}^m}, \frac{1}{a_{ji}^l})$

Consider a prioritization problem at a level with n elements, where pair-wise comparison judgments are represented by fuzzy triangular numbers $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$. As in the conventionalAHP, each set of comparisons for a level requires $\frac{n(n-1)}{2}$ judgments, which are further used to construct a positive fuzzy reciprocal comparison matrix $\tilde{A} = \tilde{a}_{ij}$ such that:

$$\begin{bmatrix} \tilde{a}_{11} & \cdots & \tilde{a}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{a}_{m1} & \cdots & \tilde{a}_{mn} \end{bmatrix}$$

Step3: Determination of composed Fuzzy column Matrix as:

	C_1	C_2	…	C_n	$\tilde{s}_i$
C_1	(1,1,1)	$(a_{12}^l, a_{12}^m, a_{12}^u)$	…	$(a_{1n}^l, a_{1n}^m, a_{1n}^u)$	$\tilde{s}_1 = (s_1^l, s_1^m, s_1^u)$
C_2	$(a_{21}^l, a_{21}^m, a_{21}^u)$	(1,1,1)	…	$(a_{2n}^l, a_{2n}^m, a_{2n}^u)$	$\tilde{s}_1 = (s_1^l, s_1^m, s_1^u)$
⋮			⋮	⋮	⋮
C_m	$(a_{m1}^l, a_{m1}^m, a_{m1}^u)$	$(a_{m2}^l, a_{m2}^m, a_{m2}^u)$	…	(1,1,1)	$\tilde{s}_m = (s_m^l, s_m^m, s_m^u)$

That:

$$\tilde{s}_1 = (s_1^l, s_1^m, s_1^u) = \left(\frac{a_{11}^l + a_{12}^l + \dots + a_{1n}^l}{\sum_{i=1}^n \sum_{j=1}^n a_{ij}^u}, \frac{a_{11}^m + a_{12}^m + \dots + a_{1n}^m}{\sum_{i=1}^n \sum_{j=1}^n a_{ij}^m}, \frac{a_{11}^u + a_{12}^u + \dots + a_{1n}^u}{\sum_{i=1}^n \sum_{j=1}^n a_{ij}^m}\right)$$

(1)

Step4: Determination of composed Crisp column Matrix based on value degree as:

	C_1	C_2	…	C_n	$\tilde{s}_i$	s_i
C_1	(1,1,1)	$(a_{12}^l, a_{12}^m, a_{12}^u)$	…	$(a_{1n}^l, a_{1n}^m, a_{1n}^u)$	$\tilde{s}_1 = (s_1^l, s_1^m, s_1^u)$	s_1
C_2	$(a_{21}^l, a_{21}^m, a_{21}^u)$	(1,1,1)	…	$(a_{2n}^l, a_{2n}^m, a_{2n}^u)$	$\tilde{s}_1 = (s_1^l, s_1^m, s_1^u)$	s_2
⋮			⋮	⋮	⋮	…
C_m	$(a_{m1}^l, a_{m1}^m, a_{m1}^u)$	$(a_{m2}^l, a_{m2}^m, a_{m2}^u)$	…	(1,1,1)	$\tilde{s}_m = (s_m^l, s_m^m, s_m^u)$	s_m

With

VL:(0,0.5,2); L:(1,2,3); ML:(2,3.5,4); M:(4,5,6); MH (5,6.5,8); H:(7,8,9); VH (8,9.5,10)

$$V(\tilde{A} > \tilde{B}) = \begin{cases} 1 & ; \quad a_m \geq b_m \\ \frac{b_l - a_u}{(a_m - a_u) - (b_m - b_l)} & ; \text{els} \end{cases} \quad (2)$$

$V(\tilde{A} > \tilde{E}, \tilde{C}, \tilde{D}, \dots) = \text{Min}\{V(\tilde{A} > \tilde{B}), V(\tilde{A} > \tilde{C}), V(\tilde{A} > \tilde{D}), \dots\} = \alpha$

$V(\tilde{B} > \tilde{A}, \tilde{C}, \tilde{D}, \dots) = \text{Min}\{V(\tilde{B} > \tilde{A}), V(\tilde{B} > \tilde{C}), V(\tilde{B} > \tilde{D}), \dots\} = \beta$

$V(\tilde{C} > \tilde{A}, \tilde{B}, \tilde{D}, \dots) = \text{Min}\{V(\tilde{C} > \tilde{A}), V(\tilde{C} > \tilde{B}), V(\tilde{C} > \tilde{D}), \dots\} = \gamma$

$V(\tilde{D} > \tilde{A}, \tilde{B}, \tilde{C}, \dots) = \text{Min}\{V(\tilde{D} > \tilde{A}), V(\tilde{D} > \tilde{B}), V(\tilde{D} > \tilde{C}), \dots\} = \lambda$

That:

$$s_1 = s_A = \frac{\alpha}{\alpha+\beta+\gamma+\lambda},\ s_2 = s_D = \frac{\beta}{\alpha-\beta+\gamma+\lambda},\ s_3 = s_C = \frac{\gamma}{\alpha+\beta+\gamma+\lambda},\ s_4 = s_D = \frac{\lambda}{\alpha+\beta+\gamma+\lambda} \quad (3)$$

Step5: Consistency check and deriving priorities and Weighting & Ranking. This step checks for consistency and extracts the priorities from the pair-wise comparison matrices. In existing fuzzy AHP methods, only a few past studies have addressed the issue of checking for inconsistencies in pair-wise comparison matrices. According to Buckley (1985), a fuzzy comparison matrix $\tilde{A} = \tilde{a}_{ij}$isconsistent if$\tilde{a}_{ik} \otimes \tilde{a}_{kj} \approx \tilde{a}_{ij}$ where$i, j, k = 1,2, \ldots, n$ and$\otimes$isfuzzy multiplication, and $\approx$ denotes fuzzy equal to. Oncethe pair-wise comparison matrix,$\tilde{A}$, passes the consistencycheck, fuzzy priorities $\tilde{w}_i$can be calculated with conventional fuzzy AHP methods. Then, the priority vector$(w_1, w_2, \ldots, w_n)^T$can be obtained from the comparisonmatrix by applying a prioritization method. Briefly, stages of Consistency check is as below:

Stage1: deviation the fuzzy triangular matrix to tow matrix as;

1. Interval numbers of triangular judgments: $A^m = [a_{ijm}]$
2. Geometric average of upper and low limits of triangular numbers: $A^g = \sqrt{a_{iju} a_{ijl}}$

Stage2: Calculating of weight vector for each matrix using saaty's method as below:

$$W_i^m = \frac{1}{n}\sum_{j=1}^{n} \frac{a_{ijm}}{\sum_{i=1}^{n} a_{ijm}}; \quad W^m = [W_i^m] \quad (4)$$

$$W_i^g = \frac{1}{n}\sum_{j=1}^{n} \frac{\sqrt{a_{iju} a_{ijl}}}{\sum_{i=1}^{n} \sqrt{a_{iju} a_{ijl}}}; \quad W^g = [W_i^g] \quad (5)$$

Stage3: Calculating the biggest of specific amount for each matrix as below:

$$\lambda_{max}^m = \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ijm}\left(\frac{W_j^m}{W_i^m}\right) \quad , \quad (6)$$

$$\lambda_{max}^g = \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} \sqrt{a_{iju} a_{ijl}}\left(\frac{W_j^g}{W_i^g}\right) \quad (7)$$

Stage4: Calculating of consistency index using the relations:

$$CI^m = \frac{(\lambda_{max}^m - n)}{n-1} \ , \ CI^g = \frac{(\lambda_{max}^g - n)}{n-1} \quad (8)$$

Stage5: Calculating of consistency rate using the relations:

$$CR^m = \frac{CI^m}{RI^m}, \quad CR^g = \frac{CI^g}{RI^g} \quad (9)$$

If both of indexes were less of 0.10, Then fuzzy matrix is consistent, and if they were most of 0.10, then decision makers should revise the prioritization, and if one of these indexes were most of 0.10, then decision makers should revise the interval amounts of triangular judgments (Buckly, 1985).

5. Evaluation of the application barriers of GSCM

Step1: Now we use fuzzy AHP to evaluate the application barriers of GSCM in Abzarsazi Industries of Iran. We will use a numerical illustration to show our method. First, set up the analytic hierarchy model of GSCM evaluation as figure1:

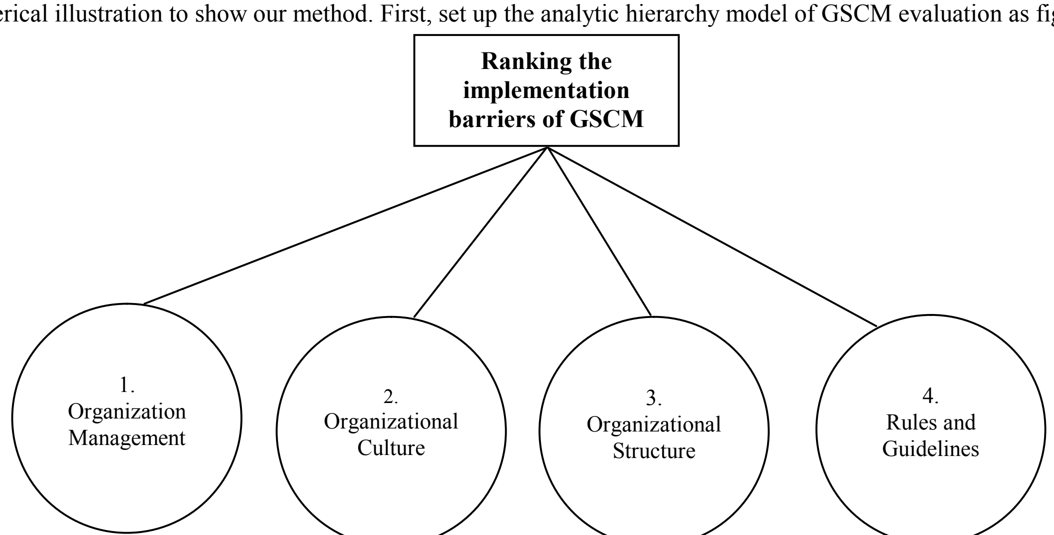

Figure1. The hierarchy model of the GSCM evaluation

Step2: Next, we give the Fuzzy Pair-wise Matrix for GSCM evaluation.

On the other hand, in this step, a questionnaire prepared and ten experts of Abzarsazi Industries in GSCM completed it with linguistic variables. To convert the fuzzy linguistic variables to fuzzy number can use the table4:

Table 4: Linguistic variables for paired comparison criteria

VL (Very low)	0	0.5	2
L (Low)	1	2	3
ML (Medium Low)	2	3.5	4
M (Medium)	4	5	6
MH (Medium High)	5	6.5	8
H (High)	7	8	9
VH (Very High)	8	9.5	10

Finally, the geometric fuzzy pair-wise matrix is calculated as figure2.

Fuzzy Pair-wise Matrix	C1			C2			C3			C4		
C1	1.00	1.00	1.00	1.00	2.00	3.00	4.00	5.00	6.00	0.00	0.50	2.00
C2	0.33	0.50	1.00	1.00	1.00	1.00	7.00	8.00	9.00	2.00	3.50	4.00
C3	0.17	0.20	0.25	0.11	0.13	0.14	1.00	1.00	1.00	0.00	0.50	2.00
C4	0.50	2.00	1000.00	0.25	0.29	0.50	0.50	2.00	1000.00	1.00	1.00	1.00

Figure2. The geometric Fuzzy Pair-wise Matrix

Step3: Next we calculate the composed Fuzzy column Matrix in excel software as figure3:

composed Fuzzy column Matrix	Si		
C1	0.00	0.30	0.60
C2	0.01	0.45	0.76
C3	0.00	0.06	0.17
C4	0.00	0.18	100.76

Figure3. The composed Fuzzy column Matrix

Step4: In this step, we determinate the composed Crisp column Matrix based on value degree as figure4:

composed Crisp column Matrix	C1	C2	C3	C4
C1	1	1	0.41843	0.998886
C2	0.792044	1	0.297901	0.997331
C3	1	1	1	1
C4	1	1	0.583853	1
V(Ci>C1,C2,C3,C4)	0.792044	1	0.297901	0.997331

Figure4. The composed Crisp column Matrix based on value degree

Step5: Consistency check and deriving priorities and Weighting & Ranking as figure5:

In this paper, Fuzzy AHP is implemented in the software Excel. Calculated consistency ratio by software is 0.05 and 0.04 for tow indexes, so, they represents the relative consistency of decision makers' judgments.

Weighting & Ranking	C_1	C_2	C_3	C_4
Factors	Organization Management	Organizational Culture	Organizational Structure	Rules and Guidelines
Weight	0.256551	0.32391	0.096493	0.323046
Rank	3	1	4	2

Figure5. The Weighting & Ranking of GSCM barriers

CONCLUSION

GSCM was starting debated since the quality revolution of the 1980s and supply chain revolution of the 1990s. Zhu and Sarkis (2004) defined GSCM has a ranged from green purchasing to integrated supply chains starting from suppliers. All of business activities related to green supply chain management (GSCM) have played as an important role to environmental management factors applied for the purpose of business manufacturer.

In this study, we first identified the implementation barriers of GSCM in Abzarsazi industries of Iran with presentation a hierarchy model. In finally, the barriers are ranked using Fuzzy AHP. The results show Organization Culture has great impact on success of GSCM implementation among main aspects. Also Organizational Structure has minimum impact on success of GSCM implementation among main aspects.

So this paper gives an evaluation method for GSCM in order to help researches and managers to determine the drawbacks and opportunities.

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