Agility Index Evaluation Using Fuzzy Logic in a Supply Chain Management Company

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Abstract

Agility is one of the coming challenges to the supply chain management companies. This paper presents a model to evaluate agility for supply chain management companies and answers the question that how agile a supply chain management company is. It shows a complete set of items in evaluating agility in SCM companies.The model surveys agility in responsiveness with indexes such as strategic planning, sensitivity to change and virtual enterprise; flexibility with indexes such as market flexibility, logistics flexibility,operations system flexibility and supply flexibility;competency with indexes such as integrative mechanism, shared culture, joint decision making, trust and communication; and finally quickness with indexes such as speed of new product introduction,delivery time and speed in operation.The results of S.G.S Co. show that it is in the middle range of agility. It also identifies weak factors within the organization which by improving them, the company can improve its agility index. Evaluation is done in fuzzy logic.

Keywords: agility index, fuzzy logic, supply chain management

1. Introduction

The concept of agility was first introduced in a report from the Iacocca Institute at Lehigh University in 1991. The report explained that how US corporations should move forward to become a manufacturing leader again (Nagel & Dove, 1991).

While agility has been defined in different contexts such as manufacturing, here agility in the context of supply chain is the main concern. A supply chain is a system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together via a feed-forward flow of materials and feedback flow of information Stevenes (1989). This should be expanded to include the flow of resources and cash through the supply chain Naim (1997). Hacland (1997) suggests that the term Supply Chain Management (SCM) can be used to describe a number of concepts—the processes inside a manufacturing organization, purchasing and supply management occurring within dyadic relationships; the total chain and finally a total firm network. It is suggested that the emphasis of supply chain management has changed in the past two deceased. Stuart (1997) and Dossenbach (1999) argue that approaches to supply chain management are much more systematic, focusing on relationships involved.

Christopher and Peck (2004) define supply chain agility as the ability to respond quickly to unpredictable changes in demand or supply. From their point of view, the key to an agile response is the presence of agile partners in upstream and downstream of the focal firm. Christopher and Peck (2004) define the two key characteristics of agile supply chain as visibility (the ability to see from one end of the pipeline to the other) and velocity. Papers related to agility can be mainly divided into two streams. The first category focuses on agility practices and the second group concentrates on how agility affects performance outcomes. These papers have different definition for agility.

Table 1 summarizes the key literature on agility related to both groups and the definitions that are used in these papers for agility.

Table 1. Key literature on agility and the definitions used

Paper focus	Key Literature on Agility	Definition	Performance Dimension	Associated Practices
Agile practices	Gunasekaran and Yusuf (2002)	"Capability to survive and prosper in a competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing markets, driven by customer-designed products and services".		Flexible people & technology, strategic planning & objectives, market focus
	Swafford et al. (2006)	"Capability of an organization to adapt or react to marketplace changes or to seize/exploit market opportunities with speed and quickness".		Procurement, sourcing flexibility, manufacturing flexibility, distribution, logistics flexibility
	Braunscheidel and Suresh (2009)	"Supply chain's capability to respond in a speedy manner to a changing marketplace environment".		Joint planning, customer responsiveness, visibility, demand, response
Agility and performance	Sharifi and Zhang (2001)	"Ability to sense, respond to, and exploit anticipated or unexpected changes in the business environment".	Delivery responsiveness, delivery speed, product model flexibility (customization), product introduction flexibility, volume flexibility	Advanced soft & hard technologies, internal networks, worker empowerment, concurrent teams
	Prince and Kay (2003)	"Capabilities of an enterprise to reconfigure itself in response to sudden changes in ways that are cost effective, timely, robust and of broad scope".	Delivery speed, product introduction speed; stable unit cost, changeover flexibility	Information & communications technologies; computer controlled manufacturing; modular facilities
	Brown And Bessant (2003)	"Ability to respond quickly and effectively to changes in market demand".	Proactive & reactive flexibility, delivery speed, design quality (customization), cost efficiency	JIT, TQM, customer linkages, supplier alliances & information sharing, wide range of skill training, advanced information & manufacturing
	VasquesBustelo et al. (2007)	"Capability to change market requirement, maximize customer service level, minimize the cost of goods".	Cost, quality, delivery, environment, flexibility, Service	Agile HR, agile technologies, value chain integration, knowledge management, concurrent engineering

As seen above, different researchers define agility in different ways. This research takes advantage of the one from Swafford et al. (2006). They define agility as "*the supply chain's capability to adapt or respond in a speedy manner to a changing marketplace environment*". While agility has been researched in literature a lot (Gunasekaran & Yusuf, 2002; Swafford et al., 2006; Braunscheidel & Suresh, 2009; Sharifi & Zhang, 2001; Prince & Kay, 2003; Brown & Bessant, 2003; Bustelo et al., 2007) literature still has a deep gap regarding what exactly is agility and how is it define in the context of supply chain and second how agility can be measured in supply chain management companies. The research question is highly important since it is argued that in today's markets competition is no longer based on company versus company model, but instead is supply chain versus supply chain (O'Marah, 2001).

1.1 Developing Agile Indexes in 3 Grades for Supply Chain Management

Different researchers present different frameworks for agility. According to Hoek (2000) agility in the supply chain is linked to customer sensitivity, virtual integration, process integration and network integration. Additionally, agile supply chains according to Van der Vorst et al. (2001) are: market sensitive (the supply chain is capable of reading the real demand and responding to it), virtual (using information technology between buyers and suppliers to share the data), process integrated (collaborative working between buyers and suppliers such as joint product development, common systems and shared information) and network based (relationships with partners must be managed in a network, committed to more agile relationships with final customers).Sharifi and Zhang (1999) introduce four agile capabilities in their conceptual model for agility which are responsiveness, competency, flexibility and quickness. We find these capabilities the most comprehensive ones for agile supply chains so we develop our model based on these four capabilities. We define the second and third grade indexes for each of them through other papers which will be mentioned later. The definition and the sub-indexes of these capabilities are as following:

1) Responsiveness is the ability to identify changes and respond to them. This has been itemized as follows:

Strategic planning: subindexes are taken from Gunasekaran et al. (2008) Sensitivity to change: subindexes are taken from Gunasekaran et al. (2008); Lin et al. (2005); Ismail & Sharifi (2006) Virtual enterprise: subindexes are taken from Gunasekaran et al. (2008); Faisal et al. (2007); and Lin et al. (2006).

2) Competency which is the extensive set of abilities that provides productivity efficiency and effectiveness of activities towards the aims of a company (Sharifi & Zhang, 1999) and is itemized to: Integrative mechanism, Shared culture, Joint decision making, Trust and Communication. Subindexes are taken from Spekman (2002).

3) Flexibility is the ability to process different products and achieves different objectives with the same facilities (Sharifi & Zhang, 1999) and is itemized to: Market flexibility, Logrstics flexibility, Operation system flexibility, Supply flexibility. Subindexes are taken from Duclos et al. (2003).

4) Quickness is the ability to do tasks and operations in the shortest time (Sharifi & Zhang, 1999) and is itemized to: Speed of new product introduction, Delivery time, Speed in operation. Subindexes are taken from Christopher (2000); Sharp et al. (1999); Giachetti et al. (2003); and Lin et al. (2005).

Our agile model developed for SCM companies is presented in Table 2.

Table 2. The agile model developed for SCM companies

(AC_i) 1-Grade index	(AC_{ii}) 2-Grade index	(AC_{ijk}) 3-Grade index
1. Responsiveness	1-1 Strategic Planning	AC_{1-1-1} Maintaining and developing relationships with customers
		AC_{1-1-2} Using factors based on customer satisfaction
		AC_{1-1-3} Trying for better quality
		AC_{1-1-4} Trying for decreasing costs and as a result in cast of product
		AC_{1-1-5} Using multidisciplinary teams
		AC_{1-1-6} Using IT and k.m. systems
		AC_{1-1-7} Top management support
		AC_{1-1-8} Having collaborative relationships with suppliers
		AC_{1-1-9} Using concurrent engineering

(AC_i) 1-Grade index	(AC_{ij}) 2-Grade index	(AC_{ijk}) 3-Grade index
		AC_{1-1-10} Using postponement strategy
		AC_{1-1-11} Capability in presenting high level of service before and after sale
		AC_{1-1-12} Employee empowerment
	1-2 Sensitivity to change	AC_{1-2-1} Capability in understanding changes in market
		AC_{1-2-2} Capability in understanding changes in the activities and situations of competitors
		AC_{1-2-3} Capability in understanding changes in the customer demands
		AC_{1-2-4} Capability in understanding changes in technology
		AC_{1-2-5} Capability in understanding changes in economic, social and political factors
		AC_{1-2-6} Capability in understanding changes in the actions and situations of suppliers
		AC_{1-2-7} Capability in understanding changes in demand for customized products
		AC_{1-2-8} Capability in understanding changes in speed and efficiency of the organization in data analysis
		AC_{1-2-9} Attention to strategic planning in top management
		AC_{1-2-10} Having technical and financial analysis from strategic and market information
		AC_{1-2-11} Responsiveness to demand as soon as getting the order
		AC_{1-2-12} Range of outsourcing
		AC_{1-2-13} Efficient responsiveness to customer
		AC_{1-2-14} Satisfying market from quality and cast and lead time of products
		AC_{1-2-15} Capability of remaining profitable in glut market
		AC_{1-2-16} Capability in conducting market demands towards company products and services
	1-3 Virtual Enterprise	AC_{1-3-1} Availability of data through internet for members of supply chain
		AC_{1-3-2} Using data networks and intranet for members of supply chain
		AC_{1-3-3} Updating sell data
		AC_{1-3-4} Data transfer without using paper (paperless data transfer)
		AC_{1-3-5} Using data system
		AC_{1-3-6} Using under-web softwares in supply chain
		AC_{1-3-7} Using virtual relationships between members of supply chain
		AC_{1-3-8} Using internet and other information tools for relationships out of company
2. Competency	2-1 Learning Encouragement	AC_{2-1-1} Encouraging different point of view in supply chain
		AC_{2-1-2} Developing new insights in supply chain
		AC_{2-1-3} Generating new ideas in supply chain
		AC_{2-1-4} Acceptance of new ideas
		AC_{2-1-5} Experimentation support

(AC_i) 1-Grade index	(AC_{ij}) 2-Grade index	(AC_{ijk}) 3-Grade index
		AC_{2-1-6} Encouraging new ideas
	2-2 Integrative Mechanism	AC_{2-2-1} Using electronic data exchange (EDI)
		AC_{2-2-2} Integrated business system
		AC_{2-2-3} Partner as operational part of supply/demand planning
		AC_{2-2-4} IT integration with all suppliers/customers
	2-3 Shared Culture	AC_{2-3-1} Shared continuous philosophy between the organization and suppliers
		AC_{2-3-2} Similar sense of fair play with suppliers
		AC_{2-3-3} Shared vision or mission statement
	2-4 Commitment	AC_{2-4-1} Commitment of suppliers to our organization
		AC_{2-4-2} The organization will to devote extra effort to sustaining the relationships with suppliers
		AC_{2-4-3} Vitality of maintaining the relationships
		AC_{2-4-4} Supplier will to devote energy to sustain the relationship
	2-5 Trust	AC_{2-5-1} Supplier trustworthy
		AC_{2-5-2} Having complete confidence
		AC_{2-5-3} Existence of high level of trust within the supply chain
	2-6 Communication	AC_{2-6-1} Continuous contact between organization and supplier
		AC_{2-6-2} Level of contact between organization and customer
	2-7 Joint Decision Making	AC_{2-7-1} Working with supplier on long-range plan
		AC_{2-7-2} Joint team for managing relationships
		AC_{2-7-3} Values consensus on decision-making
		AC_{2-7-4} Individuals participation in decisions that are critical to overall success
3. Flexibility	3-1 Operations System Flexibility	AC_{3-1-1} Capability in changing products if customer demands changes
		AC_{3-1-2} Capability of supplier in changing if customer demands changes
		AC_{3-1-3} Capability in changing personnel if customer demands changes
		AC_{3-1-4} Capability of supplier in changing personnel if customer demands changes
		AC_{3-1-5} Capability of supplier in changing production process if customer demands changes
	3-2 Market Flexibility	AC_{3-2-1} Capability in new product design and introduction
		AC_{3-2-2} Capability in customized production
		AC_{3-2-3} Capability in producing different product from competitor's product
		AC_{3-2-4} Time needed for presenting new product to market
		AC_{3-2-5} Using modular designs so that the product differentiation is postponed as long as possible
		AC_{3-2-6} Capability to response the changes happened in customer demand
	3-3 Logistics Flexibility	AC_{3-3-1} Changing the speed of transportation by companies having contract

(AC_i) 1-Grade index	(AC_{ij}) 2-Grade index	(AC_{ijk}) 3-Grade index
		AC_{3-3-2} Capability of transportation companies in transporting different materials
		AC_{3-3-3} Capability in packaging the production according to customer demand
		AC_{3-3-4} Capability of changing documentation method related to good transportation
		AC_{3-3-5} Capability in tracking transported productions
	3-4 Supply Flexibility	AC_{3-4-1} Number of qualified suppliers for each product
		AC_{3-4-2} Differences in cost due to buying from different suppliers
		AC_{3-4-3} Capability of suppliers in supplying different products
		AC_{3-4-4} Capability of suppliers in producing in low volumes because of low storage costs
		AC_{3-4-5} Existence of different ways and methods for product transportation from suppliers
		AC_{3-4-6} Using of min inventory and multi ordering in small batches policies
		AC_{3-4-7} possibility and transporting different productions within one batch (economic and technically)
		AC_{3-4-8} Capability of suppliers in transporting orders quickly with fastest transportation systems without extra cost
		AC_{3-4-9} Capability to adop processes to specific product
		AC_{3-4-10} Capability to down size
		AC_{3-4-11} Ability to attract a portfolio of partners that changes as customer needs change
		AC_{3-4-12} Selection the most appropriate relationships to match the specific set of circumstances
4. Speed	4-1 Speed of New Product Introduction	AC_{4-1-1} Speed of understanding new situations in market
		AC_{4-1-2} Speed of doing research
		AC_{4-1-3} Speed of introducing new product to market
	4-2 Delivery on time	AC_{4-2-1} Speed in responding changes in customer orders
		AC_{4-2-2} Speed in making decision
		AC_{4-2-3} Speed in receiving data related to demands
	4-3 Speed in Operations	AC_{4-3-1} Speed of capital refund
		AC_{4-3-2} Speed in receiving necessary data
		AC_{4-3-3} Speed in a collaboration with a new supplier
		AC_{4-3-4} Range of availability of data in supply chain
		AC_{4-3-5} Using of virtual relationships in supply chain
		AC_{4-3-6} Existence of facilities for quick decision making in supply chain (for example: intranet)
		AC_{4-3-7} Conducting concurrent activities in supply chain
		AC_{4-3-8} Speed of stock operation after production delivery
		AC_{4-3-9} Speed of preparing documentation related to productions transportation from stock

Theoretically this paper present a complete agile model for SCM companies to fill the gap seen in literature previously. It also presents a practical measurement method to evaluate agile index for SCM companies. Practically, managers can take advantage of the comprehensive model to measure their agility index and identify weak factors within their supply chain agility and try to improve them, therefore improve their agility index.

2. Method

2.1 Identifying Agility Index

Different methods for evaluating agility were mentioned in the literature. Van Hoek proposed integration agility index method as follows:

$$(\text{Agility index})_i = \sum_{j=1}^{N} A_{ij} \qquad (1)$$

Where Aij is the agility level of capability J of company i. Other authors like Ren developed their method on the basis of analytic hierarchical process (AHP). Also Yang and Li define agility as following:

$$\text{Agility index} = \sum_{i=1}^{N} R_i \times W_i \qquad (2)$$

Where; $\sum_{i=1}^{N} W_i = 1$

Where Ri is agility index and the weight of it is Wi. (Lin et al., 2005)

The above methods are easy to implement but are not suitable for evaluating agility because of the imprecise and vague definition of agility indicators. Also when a situation is characterized by either lack of evidence or the inability of the experts to make a significant assessment of an event, linguistic expressions are used.

The scoring of the above techniques can always be criticized because there are 2 limitations for scoring the agility capabilities. First, such techniques do not take in to account the ambiguity associated with the ones judgment to a number and secondly the subjective judgment and the selection of evaluators have an important influence on those methods.

Here, we used Lin method who used fuzzy logic and linguistic expressions for evaluation because fuzzy logic is suitable for the phenomena which are imprecise and vague. By this method evaluators can use linguistic terms to assess the indicators in a natural language expression and each linguistic term can be associated with a membership function (Lin et al., 2005). The novelty of the research is that the agile capabilities defined in Lin's model were for a product manufacturing company. This model is defined for SCM companies and is developed by comprehensive set of indexes.

We pursued the proposed model by Lin in order to measure how agile the sample company is (This company is introduced in the next section) and also identifying the principal obstacles to improve the agility level. In this approach, the performance ratings and importance weights of different agility capabilities assessed by experts are expressed in logistic terms.

Then appropriate fuzzy numbers are used to present the linguistic values and a simple fuzzy arithmetical operation is employed to synthesize these fuzzy numbers into one fuzzy number, which is called the fuzzy-agility-index (FAI).

Also the FAI is matched with appropriate linguistics; thereby, enabling the agility level to be expressed in linguistic terms. After that the fuzzy performance-importance index (FPII) of each agility capabilities is devised to help managers identify the main adverse factors and calls for managers to institute an appropriate action plan to improve the agility level.

2.2 Fuzzy Agility Evaluation Approach

We evaluate agile capabilities and synthesize the ratings and weights to obtain an FAI of an agile SCM and to match FAI with an appropriate agility level and to make an improvement analysis. The steps are as follows:

1) Selecting criteria for evaluation;

2) Determining the appropriate linguistic scale to assess the performance ratings and importance of agility capabilities using linguistic terms;

3) Measuring the performance and importance weights of the agility capabilities;

4) Approximating the linguistic terms by fuzzy numbers;

5) Aggregating fuzzy ratings with fuzzy weights to obtain and FAI of an enterprise;

6) Matching the FAI with an appropriate level;

7) Analyzing and identify the principal obstacles to improvement.

3. Results: Agility Evaluation in S.G.S. Co. (The Supply Chain Management Company)

The above steps for our sample company have been taken as following:

Step 1) The criteria is SazehGostarSaipa Company. S.G.S. Co. has been established in July 1985 and started its formal activity in 1990 as the first company in engineering and supplying automotive parts as well as the first supply chain management and organization of Saipa Group in Iran. The company started its operation by supplying the automotive parts for Nissan.

Widening the range of its activities constantly, SazehGostar has played an outstanding role in the development and progress of the automotive-part producing industry in Iran and currently it covers more than 500 automative-part producers in its supply network.

Step 2) On the basis of the Lin's model and considering the human way of perceiving differences, the linguistic variables{ Excellent [E], Very Good [VG], Good [G], Fair [F], Poor [P], Very Poor [VP], Worst [W]} are selected to assess the performance rating of the agility capabilities and {Very High [VH],High [H], Fairly High [FH], Medium [M], Fairly Low [FL], Low [L], Very Low [VL]} are selected to assess the importance weights of the agility capabilities (Lin et al., 2005).

Step 3) 15 persons mostly selected of managers and supervisors, answered the questionnaire about first, second and third indexes of agility. Since analysis through fuzzy logic is complicated 15 persons were selected through those who are at the strategic level of the company in order to understand the importance of all the aspects of strategy, market and competitors. They were selected from different departments such as supply,logistics, human resource, systems and information technology, engineering and development, quality, orders control and marketing, etc.They answered the questionnaires according to the company strategy,characteristics, business changes,marketing information and their knowledge and experience. Some of the results were taken by the interviews especially for those who didn't send back the questionnaires in the time and after emails for recalling the date. They used linguistic terms above to directly measure the performance rating and importance weight of the agility capabilities. Then average operation was used to aggregate the assessments.

$$R_j = (R_{j1}(+)R_{j2}(+)\ldots(+)R_{jm})/m \qquad (3)$$

$$W_j = (W_{j1}(+)W_{j2}(+)\ldots(+)W_{jm})/m \qquad (4)$$

Here m=15.

The results of aggregated performance ratings and integrated performance weights of agile capabilities measured by linguistic variables are shown in Table 3.

Table 3. Aggregated performance rating and aggregated importance weight of agility capabilities

ACi	ACij	ACijk	Wi	Wij	Wijk	Rijk
AC1	AC1-1	1-1 AC1	H	H	H	F
		2-1 AC1			FH	F
		3-1 AC1			H	F
		4-1 AC1			H	F
		5-1 AC1			FH	P
		6-1 AC1			H	F
		7-1 AC1			H	F
		8-1 AC1			FH	F

ACi	ACij	ACijk	Wi	Wij	Wijk	Rijk
		9-1 AC1			FH	P
		10-1 AC1			M	P
		11-1 AC1			FH	F
		12-1 AC1			H	F
	2 AC1	1-2 AC1		FH	FH	P
		2-2 AC1			FH	P
		3-2 AC1			H	P
		4-2 AC1			H	P
		5-2 AC1			H	F
		6-2 AC1			FH	F
		7-2 AC1			FH	P
		8-2 AC1			FH	P
		9-2 AC1			H	F
		10-2 AC1			H	P
		11-2 AC1			H	F
		12-2 AC1			FH	F
		13-2 AC1			H	G
		14-2 AC1			H	F
		15-2 AC1			FH	P
		16-2 AC1			H	P
	3 AC1	1-3 AC1		H	H	F
		2-3 AC1			H	G
		3-3 AC1			FH	G
		4-3 AC1			FH	F
		5-3 AC1			VH	VG
		6-3 AC1			H	F
		7-3 AC1			H	F
		8-3 AC1			H	F
		9-3 AC1			H	G
		10-3 AC1			H	F
		11-3 AC1			H	F
AC2	1 AC2	1-1 AC2	H	H	H	F
		2-1 AC2			H	G
		3-1 AC2			H	F
		4-1 AC2			H	G
		5-1 AC2			H	F
		6-1 AC2			H	F
	2 AC2	1-2 AC2			H	G
		2-2 AC2			H	F
		3-2 AC2			H	F
		4-2 AC2			H	F

ACi	ACij	ACijk	Wi	Wij	Wijk	Rijk
	3 AC2	1-3 AC2		H	H	F
		2-3 AC2			H	P
		3-3 AC2			H	F
	4 AC2	1-4 AC2		H	H	F
		2-4 AC2			H	G
		3-4 AC2			H	G
		4-4 AC2			H	G
	5 AC2	1-5 AC2		H	H	G
		2-5 AC2			H	F
		3-5 AC2			H	F
	6 AC2	1-6 AC2		H	H	G
		2-6 AC2			H	G
	7 AC2	1-7 AC2		H	VH	F
		2-7 AC2			H	F
		3-7 AC2			H	F
		4-7 AC2			H	P
AC3	1 AC3	1-1 AC3	H	H	H	F
		2-1 AC3			H	G
		3-1 AC3			H	F
		4-1 AC3			H	F
		5-1 AC3			H	F
	2 AC3	1-2 AC3		H	H	F
		2-2 AC3			H	P
		3-2 AC3			H	P
		4-2 AC3			H	P
		5-2 AC3			H	P
		6-2 AC3			H	G
	3 AC3	1-3 AC3		H	H	F
		2-3 AC3			H	F
		3-3 AC3			H	G
		4-3 AC3			FH	P
		5-3 AC3			H	P
	AC3-4	1-4 AC3		H	H	F
		2-4 AC3			H	F
		3-4 AC3			H	F
		4-4 AC3			H	F
		5-4 AC3			H	F
		6-4 AC3			FH	F
		7-4 AC3			FH	P
		8-4 AC3			H	F
		9-4 AC3			H	F

ACi	ACij	ACijk	Wi	Wij	Wijk	Rijk
		10-4- AC3			FH	P
		11-4 AC3			H	F
		12-4 AC3			H	F
AC4	1 AC4	1-1 AC4	H		FH	P
		2-1 AC4			H	P
		3-1 AC4			H	P
	2 AC4	1-2 AC4	H		H	P
		2-2 AC4			H	F
		3-2 AC4			H	G
	3 AC4	1-3 AC4	H		H	F
		2-3 AC4			H	F
		3-3 AC4			H	F
		4-3 AC4			H	F
		5-3 AC4			H	F
		6-3 AC4			H	G
		7-3 AC4			H	F
		8-3 AC4			H	G
		9-3 AC4			H	F

Step 4) according to Lin et al. (2005) a set of fuzzy numbers for approximating linguistic variable values was developed as listed in Table 4.

Table 4. Fuzzy numbers for approximating linguistic variable values

Performance-rating		Importance-weighting	
Linguistic vriable	Fuzzy number	Linguistic variable	Fuzzy number
(1)Worst (W)	(0, 0.5, 1.5)	(1)Very Low (VL)	(0, 0.05, 0.15)
(2)Very Poor (VP)	(1, 2, 3)	(2)Low (L)	(0.1, 0.2, 0.3)
(3)Poor (P)	(2, 3.5, 5)	(3)Fairly Low (FL)	(0.2, 0.35, 0.5)
(4)Fair (F)	(3, 5, 7)	(4)Medium (M)	(0.3, 0.5, 0.7)
(5)Good (G)	(5, 6.5, 8)	(5)Fairly high (FH)	(0.5, 0.65, 0.8)
(6)Very Good (VG)	(7, 8, 9)	(6)High (H)	(0.7, 0.8, 0.9)
(7)Excellent (E)	(8.5, 9.5, 10)	(7)Very High (VH)	(0.85, 0.95, 0.1)

Then the relation between linguistic terms and fuzzy numbers was applied and the linguistic numbers in Table 3were transferred in to fuzzy numbers.

Step 5) FAI is an information fusion, which consolidate the fuzzy ratings and fuzzy weights, of all the factors that influence the agility. FAI represents overall enterprise agility.

The membership function of FAI is used to determine the agility level. According to the fuzzy index of the agility the ACij can be calculated as:

$$AC_{ij}= \sum_{k=0}^{n} W_{ijk} \otimes AC_{ijk} / \sum_{k=1}^{n} W_{ijk} \tag{5}$$

Where ACij and Wijk respective lyre present the fuzzy performance rating and fuzzy importance weight of the agility element capability. Fuzzy index of each grade of agility capabilities are calculated from formula 5 and are presented in Table 5.

Table 5. Fuzzy index of each grade of agility capabilities

AC_i	AC_{ij}	R_{ij}	R_{ijk}
AC_1	$_1$-AC_1	3.2, 4.8, 7.9)(	(2.8, 4.9, 10.2)
	$_2$-AC_1		(2.6, 3.7, 5.9)
	$_3$-AC_1		(3.9, 5.7, 7.5)
AC_2	$_1$-AC_2	3.7, 4.8, 7.1)(	(3.7, 5.3, 7.3)
	$_2$-AC_2		(3.5, 5.4, 7.3)
	$_3$-AC_2		(2.6, 4.5, 6.3)
	$_4$-AC_2		(4.5, 4.5, 7.8)
	$_5$-AC_2		(3.6, 5.5, 7.3)
	$_6$-AC_2		(5, 6.5, 8)
	$_7$-AC_2		(2.8, 1.7, 6.5)
AC_3	$_1$-AC_3	(4, 4.3, 7.4)	(3.4, 5.3, 10.8)
	$_2$-AC_3		(2.6, 2.5, 5.8)
	$_3$-AC_3		(7.2, 4.8, 6.4)
AC_4	$_1$-AC_4	(2.9, 4.6, 6.3)	(2, 3.5, 5)
	$_2$-AC_4		(3.3, 5, 6.6)
	$_3$-AC_4		(2.9, 4.6, 6.3)

Finally FAI is calculated as following:FAI = [(0.7, 0.8, 0.9) $\otimes$ (3.2, 4.8, 7.9) $\oplus$ (0.7, 0.8, 0.9) $\otimes$ (3.7, 4.8, 7.1) $\oplus$ (0.7, 0.8, 0.9) $\oplus$ (4, 4.3, 7.4) $\oplus$ (7, 0.8, 0.9) $\otimes$ (2.9, 4.6, 6.3)] / [(0.7, 0.8, 0.9) $\oplus$ (0.7, 0.8, 0.9) $\oplus$ (0.7, 0.8, 0.9) $\oplus$ (7, 0.8, 0.9)] = (3.4, 4.6, 7.2)

Step 6) Once the FAI has been obtained to identify the level of agility, the FAI can be further matched with the linguistic label whose membership function is the same as (or closest to) the membership function of the FAI from the natural-language expression set of agility label (AL).

It is recommended that the Euclidean distance method be utilized because it is the most intuitive form of human perception of proximity.

In this case the natural-language expression set AL= {Extremely Agile [EA], Very Agile [VA], Agile [A], Fairly [F], Slowly [S]} is selected for labeling and corresponding membership functions are shown in Fig 1.

Fuzzy set of S is (0, 1.5, 3), fuzzy set of F is (1.5, 3, 4.5), fuzzy set of A is (3.5, 5, 6.5), fuzzy set of VA is (5.5, 7, 8.5) and fuzzy set of EA is (7, 8.5, 10) (Lin et al., 2005).

Then by using the Euclidean distance method, the Euclidean distance D from the FAI to each member in set AL is calculated.

$$D(FAI , AL_i) = \{ \sum_{x\in\rho} (f_{FAI}(x) - f_{ALi}(x))^2 \}^{1/2} \tag{6}$$

P= {x0, x1, …,xm} $\subset$ [0, 10] so 0=x0<x1<…<xm = 10 to simplify let P= {0, 0.5, 1, …, 9.5, 10}

Where $\mathbf{f}_A(x)= \begin{cases} (x\text{-}a) / (b\text{-}a) & a{\leq}x{\leq}b \\ \\ 0 & \text{otherwise} \end{cases}$

Is the function of fuzzy set (a, b, c)

D(FAI, EA) = 2.63739/ D(FAI, VA) = 2.71944/ D(FAI, A) = 2.50144/ D(FAI, F) = 2.87548/ D(FAI, S) = 2.6373

Thus by matching a linguistic label with the minimum D, the agility index level of S.G.S can be identified as agile as shown in Fig. 1.
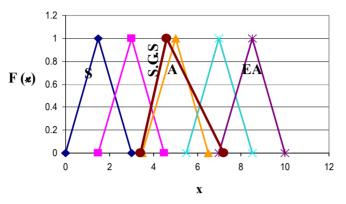

Figure 1. Linguistic levels to match FAI

Step 7) For identifying principal obstacles (low performance rating and high importance) we must have score for each of agility indexes in order to compare them with each other .So FpII (fuzzy performance—importance index) is defined as follows:

$$F_{pII} = W'_{ijk} \otimes AC_{ijk} \qquad (7)$$

$$W'_{ijk} = (1, 1, 1) \ominus W_{ijk} \qquad (8)$$

Calculated $\mathbf{F_{pII}}$ are shown in Table 6.

Table 6. Fuzzy performance-importance indexes of agility capabilities

Agility Capability	Aggregated Fuzzy Rating	Perf.	W_{ijk}	W_{ijk} - (1, 1, 1)	$FpII_{ijk}$	Ranking Score
$_{1\text{-}1\text{-}}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{2\text{-}1\text{-}}AC_1$	(3, 5, 7)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.6, 1.75, 3.5)	2.274
$_{3\text{-}1\text{-}}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{4\text{-}1\text{-}}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{5\text{-}1\text{-}}AC_1$	(2, 3.5, 5)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.4, 1.26, 2.5)	1.627
$_{6\text{-}1\text{-}}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{7\text{-}1\text{-}}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{8\text{-}1\text{-}}AC_1$	(3, 5, 7)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.6, 1.75, 3.5)	2.274
$_{9\text{-}1\text{-}}AC_1$	(2, 3.5, 5)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.4, 1.26, 2.5)	1.627
$_{10\text{-}1\text{-}}AC_1$	(2, 3.5, 5)		(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.6, 1.75, 3.5)	1.985
$_{11\text{-}1\text{-}}AC_1$	(3, 5, 7)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.6, 1.75, 3.5)	2.274
$_{12\text{-}1\text{-}}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{1\text{-}2\text{-}}AC_1$	(2, 3.5, 5)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.4, 1.26, 2.5)	1.627
$_{2\text{-}2\text{-}}AC_1$	(2, 3.5, 5)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.4, 1.26, 2.5)	1.627
$_{3\text{-}2\text{-}}AC_1$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028
$_{4\text{-}2\text{-}}AC_1$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028
$_{5\text{-}2\text{-}}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{6\text{-}2\text{-}}AC_1$	(3, 5, 7)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.6, 1.75, 3.5)	2.274

Agility Capability	Aggregated Fuzzy Rating	Perf.	W_{ijk}	$W_{ijk} - (1, 1, 1)$	$FpII_{ijk}$	Ranking Score
$_{7\text{-}2}\text{-}AC_1$	(2, 3.5, 5)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.4, 1.26, 2.5)	1.627
$_{8\text{-}2}\text{-}AC_1$	(2, 3.5, 5)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.4, 1.26, 2.5)	1.627
$_{9\text{-}2}\text{-}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{10\text{-}2}\text{-}AC_1$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028
$_{11\text{-}2}\text{-}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{12\text{-}2}\text{-}AC_1$	(3, 5, 7)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.6, 1.75, 3.5)	2.274
$_{13\text{-}2}\text{-}AC_1$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{14\text{-}2}\text{-}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{15\text{-}2}\text{-}AC_1$	(2, 3.5, 5)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.4, 1.26, 2.5)	1.627
$_{16\text{-}2}\text{-}AC_1$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028
$_{1\text{-}3}\text{-}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{2\text{-}3}\text{-}AC_1$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{3\text{-}3}\text{-}AC_1$	(5, 6.5, 8)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(1, 2.275, 4)	2.715
$_{4\text{-}3}\text{-}AC_1$	(3, 5, 7)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.6, 1.75, 3.5)	2.274
$_{5\text{-}3}\text{-}AC_1$	(7, 8, 9)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.7, 1.6, 2.7)	1.95
$_{6\text{-}3}\text{-}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{7\text{-}3}\text{-}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{8\text{-}3}\text{-}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{9\text{-}3}\text{-}AC_1$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{10\text{-}3}\text{-}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{11\text{-}3}\text{-}AC_1$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{1\text{-}1}\text{-}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{2\text{-}1}\text{-}AC_2$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{3\text{-}1}\text{-}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{4\text{-}1}\text{-}AC_2$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{5\text{-}1}\text{-}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{6\text{-}1}\text{-}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{1\text{-}2}\text{-}AC_2$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{2\text{-}2}\text{-}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{3\text{-}2}\text{-}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{4\text{-}2}\text{-}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{1\text{-}3}\text{-}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{2\text{-}3}\text{-}AC_2$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.1, 0.7, 1.5)	1.028
$_{3\text{-}3}\text{-}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{1\text{-}4}\text{-}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{2\text{-}4}\text{-}AC_2$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{3\text{-}4}\text{-}AC_2$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{4\text{-}4}\text{-}AC_2$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{1\text{-}5}\text{-}AC_2$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703

Agility Capability	Aggregated Fuzzy Rating	Perf.	W_{ijk}	$W_{ijk} - (1, 1, 1)$	$FpII_{ijk}$	Ranking Score
$_{2\text{-}5\text{-}}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{3\text{-}5\text{-}}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{1\text{-}6\text{-}}AC_2$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{2\text{-}6\text{-}}AC_2$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{1\text{-}7\text{-}}AC_2$	(3, 5, 7)		(0.85, 0.95, 1)	(0, 0.05, 0.15)	(0, 0.25, 1.05)	0.324
$_{2\text{-}7\text{-}}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{3\text{-}7\text{-}}AC_2$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{4\text{-}7\text{-}}AC_2$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028
$_{1\text{-}1\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{2\text{-}1\text{-}}AC_3$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{3\text{-}1\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{4\text{-}1\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{5\text{-}1\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{1\text{-}2\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{2\text{-}2\text{-}}AC_3$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028
$_{3\text{-}2\text{-}}AC_3$	(2, 3.5, 5)		(0.85, 0.95, 1)	(0, 0.05, 0.15)	(0, 0.175, 0.75)	0.516
$_{4\text{-}2\text{-}}AC_3$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028
$_{5\text{-}2\text{-}}AC_3$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028
$_{6\text{-}2\text{-}}AC_3$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{1\text{-}3\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{2\text{-}3\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{3\text{-}3\text{-}}AC_3$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{4\text{-}3\text{-}}AC_3$	(2, 3.5, 5)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.4, 1.26, 2.5)	1.627
$_{5\text{-}3\text{-}}AC_3$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028
$_{1\text{-}4\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{2\text{-}4\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{3\text{-}4\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{4\text{-}4\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{5\text{-}4\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{6\text{-}4\text{-}}AC_3$	(3, 5, 7)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.6, 1.75, 3.5)	2.274
$_{7\text{-}4\text{-}}AC_3$	(2, 3.5, 5)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.4, 1.26, 2.5)	1.627
$_{8\text{-}4\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{9\text{-}4\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{10\text{-}4\text{-}}AC_3$	(2, 3.5, 5)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.4, 1.26, 2.5)	1.627
$_{11\text{-}4\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{12\text{-}4\text{-}}AC_3$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{1\text{-}1\text{-}}AC_4$	(2, 3.5, 5)		(0.5, 0.65, 0.8)	(0.2, 0.35, 0.5)	(0.4, 1.26, 2.5)	1.627
$_{2\text{-}1\text{-}}AC_4$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028
$_{3\text{-}1\text{-}}AC_4$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028

Agility Capability	Aggregated Fuzzy Rating	Perf.	W_{ijk}	W_{ijk} - (1, 1, 1)	$FpII_{ijk}$	Ranking Score
$_{1-2-}AC_4$	(2, 3.5, 5)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.2, 0.7, 1.5)	1.028
$_{2-2-}AC_4$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{3-2-}AC_4$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.703
$_{1-3-}AC_4$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{2-3-}AC_4$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{3-3-}AC_4$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{4-3-}AC_4$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{5-3-}AC_4$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{6-3-}AC_4$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{7-3-}AC_4$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413
$_{8-3-}AC_4$	(5, 6.5, 8)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.5, 1.3, 2.4)	1.703
$_{9-3-}AC_4$	(3, 5, 7)		(0.7, 0.8, 0.9)	(0.1, 0.2, 0.3)	(0.3, 1, 2.1)	1.413

Now, FPIIs must be ranked. Here, Chen and Howangs left and right fuzzy ranking method is used since it not only preserves the ranking order but also consider the absolute location of each fuzzy number (Lin et al., 2005) .In Chen and Hawng's left and right fuzzy ranking method:

$$\text{Fuzzy maximizing set is } f_{max}(x)= \begin{cases} x, & 0 \le x \le 10 \\ 0, & \text{otherwise} \end{cases}$$

$$\text{Fuzzy minimizing set is } f_{min}(x)= \begin{cases} 10-x, & 0 \le x \le 10 \\ 0, & \text{otherwise} \end{cases}$$

The right score of F_{pII} is $U_R(FPII) = \sup [f_{FPII}(x) \wedge f_{max}(x)]$,

The left score of F_{pII} is $U_L(FPII) = \sup [f_{FPII}(x) \wedge f_{min}(x)]$,

Finally the total score of F_{pII} is $U_T(FPII) = [U_R(FPII) + 10 - U_L(FPII)] / 2$,

As mentioned in the pareto's principle, resources should be used in the improvement of critical obstacles to identify the most critical obstacles. Scale (1.028) was set as the management thereshold to distinguish which critical obstacles need to be improved. The results are highlightened in Table6.

The most critical factors therefore, are:

Suitable agility providers must be selected to improve these factors.

1) AC_{2-7-1} working on supplier on long-range plan
2) AC_{3-2-3} Capability in producing different product from competitors

4. Discussion

This paper answered the question that how agile an SCM company is. Also it showed a complete set of items which must be mentioned in evaluating agility in a SCM company.

The result of S.G.S Co. shows that it is in the middle range of agility. As it is stated in fuzzy value it assures you that the decision made in selection will not be biased. It also identifies weak factors within the organization which by improving them, the company can improve its agility index.

This paper presents a model for agility and a method to evasulate agility in SCM companies.It is fair to point out

that this work should be seen as the starting point that investigatesagility in SCM companies. Therefore, its limitations should be taken into consideration to improve the SCM agility by other researchers. Thus, the model should be completed for SCM companies by other researchers. Also it can be computerized to decrease the time and possible errors. It would be necessary to improve the method to compare the result with another evaluation process as well.

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Appendix A

Fuzzy numbers arithmetic operations

Let A1 and A2 be two triangular fuzzy numbers where A1= (a1,b1,c1) and A2=(a2,b2,c2).According to the extension principle ,the triangular fuzzy numbers addition, subtraction and multiplication operations of A1 and A2 Are defined as follows:

Fuzzy numbers addition $\oplus$:

A1 $\oplus$ A2 = (a1,b1,c1) $\oplus$ (a2,b2,c2)= (a1+a2,b1+b2,c1+c2)

Fuzzy numbers subtraction $\ominus$:

A1 $\ominus$ A2 = (a1,b1,c1) $\ominus$ (a2,b2,c2)= (a1-a2,b1-b2,c1-c2)

Fuzzy numbers multiplication $\otimes$:

A1 $\otimes$ A2 = (a1,b1,c1) $\otimes$ (a2,b2,c2)= (a1 ×a2,b1×b2,c1×c2)

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