AGILITY EVALUATION IN PUBLIC SECTOR USING FUZZY LOGIC

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Abstract. Agility metrics are difficult to define in general, mainly due to the multidimensionality and vagueness of the concept of agility itself. In this paper, a knowledge-based framework is proposed for the measurement and assessment of public sector agility using the A.T.Kearney model. Fuzzy logic provides a useful tool for dealing with decisions in which the phenomena are imprecise and vague. In the paper, we use the absolute agility index together with fuzzy logic to address the ambiguity in agility evaluation in public sector in a case study.

1. Introduction

Change and uncertainty dominate today's business environment. The competition is truly global, with fragmented markets and customers expecting to get the best product or service at the best price and with immediate availability. Success for an organization is dependent on how well it can react and adapt to this environment. Meeting customer demands requires a high degree of flexibility, low-cost/low-volume manufacturing and service skills, and short delivery times [7].

To maneuver and thrive in this environment requires that enterprises not just accommodate themselves to the changing environment but also seize the change and put it to competitive advantage. Since the 1990s, researchers have recognized a need for this ability, which they called ed it agility [1].

Governments also need to respond to a changing and uncertain environment. However governments and corporations have important differences. Governments are accountable to citizens rather than shareholders; undertake activity that would be deemed unprofitable in private markets, and have the power to impose obligations and penalties. Nevertheless, the public sector is not immune to the factors that drive the corporate sector to become more agile [10].

Scientific literature provides very few specific studies proposing a structured framework for evaluating agility in the public sector. This paper makes an attempt to fill this lack, by developing an integrated methodology for agility evaluation using fuzzy logic. Since Zadeh introduced fuzzy set theory, it has been widely developed in theory and application [5]. Fuzzy logic provides an effective means of dealing with problems involving imprecise and vague phenomena and, since it does not make any

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global assumptions regarding independence, exhaustiveness, or exclusiveness, can tolerate a blurred boundary in definitions. Today, fuzzy logic has found significant applications in management decisions and fuzzy concepts enable assessors to use linguistic terms to assess indicators in natural language expressions, where each linguistic term is associated with a membership function [8]. .

2. A Theoretical View of Agility

The concept of "agility" was introduced by researchers at the Iacocca Institute (1991), and since then it has received increasing attention from both research and industrial communities. From 1990s until recently, many publications on the subject have attempted to provide a definition of agility. The currently accepted definitions relate agility to the ability of companies to respond quickly and effectively to (unexpected) changes in market demand with the aim of meeting varied customer requirements, in terms of price, specification, quality, quantity, and delivery. Agile enterprises react quickly and effectively to changing markets, driven by customized products and services. Moreover, agility directly affects an organization's capability to produce and deliver new products in a cost-efficient way. Decrease in manufacturing costs, increased customer satisfaction, removal of non-value added activities and increased competitiveness are among the benefits that can be achieved with agile strategies [3].

Goldman et al. describe four dimensions of agility: (1) enriching the customer, (2) cooperating to enhance competitiveness, (3) organizing to master change and uncertainty, and (4) leveraging the impact of people and information. Many researchers focus on the ability to respond to change [1].

Tsourveloudis and Valavanis say agility is more formally defined as the ability of an enterprise to operate profitably in a rapidly changing and continuously fragmenting global market environment by producing high-quality, high-performance, customer-configured goods and services [14].

On the other hand, according to Zain et al. agility is a response to the challenges posed by a business environment dominated by change and uncertainty. It involves a new way of doing business and reflects a new mind-set for making, selling, and buying, an openness to new forms of commercial relationships, and new measures for assessing the performance of companies and people [15]. Swafford et al. believe that agility is all about customer responsiveness and mastering market turbulence [13] whereas Sherehiy et al. define agility as the successful application of competitive bases such as speed, flexibility, innovation, and quality by the means of the integration of reconfigurable resources and the optimal use of the knowledge-rich environment to provide customer-driven products and services in a fast changing environment [12]. Despite the differences, all definitions of "agility" emphasize the speed and flexibility as the primary attributes of an agile organization.

2.1. Agile Attributes.

Kidd suggests that agility can be achieved through the integration of organization, highly skilled and knowledgeable people and advanced technologies. A similar view is expressed by Goldman et al. and Gunasekaran who presents "enriching the customer", "co-operation", "organizing to master change

and uncertainty" and "leveraging the impact of people and information", as the four main dimensions of agility. Flexibility is also advocated as the basis of agility by Dove and, more recently, by Swafford et al. A comprehensive taxonomy of agile attributes was proposed by Yusuf et al. who identified 32 attributes characterizing an agile enterprise, ranging from "Concurrent execution of activities", to "Employee satisfaction"; attributes were grouped into 10 decision domains. The set of agile attributes defined by Yusuf et al. has been used in many subsequent studies [3].

2.2. **Agile Enablers.** One of the first attempts to provide a definition, as well as a comprehensive set, of agile enablers was made by Gunasekaran. According to the author, agile enablers are technologies which are critical to successfully accomplish agile manufacturing [11]. The author discusses seven agility enablers, namely "virtual enterprise formation tools/metrics", "physically distributed teams and manufacturing", "rapid partnership formation tools/metrics", "concurrent Engineering", "integrated product/production/business information system", "rapid prototyping tools", and "electronic commerce".

Recently, a thorough review of agile strategies and technologies was carried out by Gunasekaran and Yusuf and, as a result, many enablers were added to these. In fact, the authors identify about 60 viable leverages for agile manufacturing, which were categorized into 4 main groups, namely "strategic planning", "product design", "virtual enterprise", and "Information Technology" [3].

3. Agile Government

Agile government has the capacity to understand and meet the public's needs in the short term, adapt to trends and issues in the forseeable future, and shape public needs over the long term. It recognizes the imperatives for ongoing reform and adaptation to deliver government policy, regulation, enforcement, and services that continue to meet and anticipate societal needs [10].

In today's world, the phrase "agile government" is not an oxymoron. Political, societal, economic and technological forces are affecting governments and their decisions with increasing speed. Citizens and businesses demand faster and more personalized service, and policies must be developed and implemented more quickly than before [2].

In 2006, the State Services Authority released a report on The Future of the Public Sector in 2025. The report, which identified seven future issues and challenges for the public sector concluded that the future is shaped by a multitude of internal and external drivers of change which are unpredictable. These drivers – from movements in the economic cycle to climate change to shifts in social values – can lead to unforeseen consequences. As such, short term responsiveness, medium term adaptation, and long term vision and foresight play a crucial role in enabling governments to operate in a changing and uncertain world. One of these is fostering agility to support a high performing public sector. The uncertainty that the future holds means that the public sector cannot predict many of the challenges that it will confront. And hence requires agility in its systems and structures. [10].

In government, agility means understanding and meeting the needs of citizens in the short term, adapting structures and services to address medium term trends, and shaping the needs in the long term. In practice, an agile government needs to develop its capacity in the following areas:

- Short term responsiveness–responding to the public's day to day needs through choice, voice and personalization
- Strategic adaptation–learning from and scaling up innovation to improve public service systems over the long run
- Outcomes focus–focusing on end results to address cross-cutting issues
- Long term shaping–positively intervening in society to affect long term trends, creating new opportunities and preventing or reducing problems before they arise [10].

3.1. **The Model of Agile Government.** In 2003, A.T.Kearney embarked on research initiative to better understand how government departments and agencies in eight OECD (Organization for Economic Cooperation and Development) countries[1] are working to become more agile and to understand the relationship between agility and success in meeting the demands of modern government. In partnership with the Public Policy Group of the London School of Economics, A.T.Kearney conducted in-depth surveys and interviews with government agency leaders and senior civil servants who design and implement change strategies and presented the model shown in Figure 1.

4. Fuzzy Method for Agility Evaluation

The framework of the fuzzy agility evaluation method (FAEM), proposed by Lin et al. [8] in 2006, comprises three main parts. The first part involves examining business operation environments, measuring agility drivers and identifying agile capabilities, the second part assesses the agile-enabled attributes and synthesizes fuzzy ratings and weights to obtain the fuzzy agility index (FAI) of the organization and the fuzzy performance importance index for each agile attribute (AA), and, finally, the third part of the framework matches the FAI with an appropriate linguistic term to identify the agility level and selects major barriers to enable managers to proactively implement appropriate improving measures. A stepwise description is presented below:

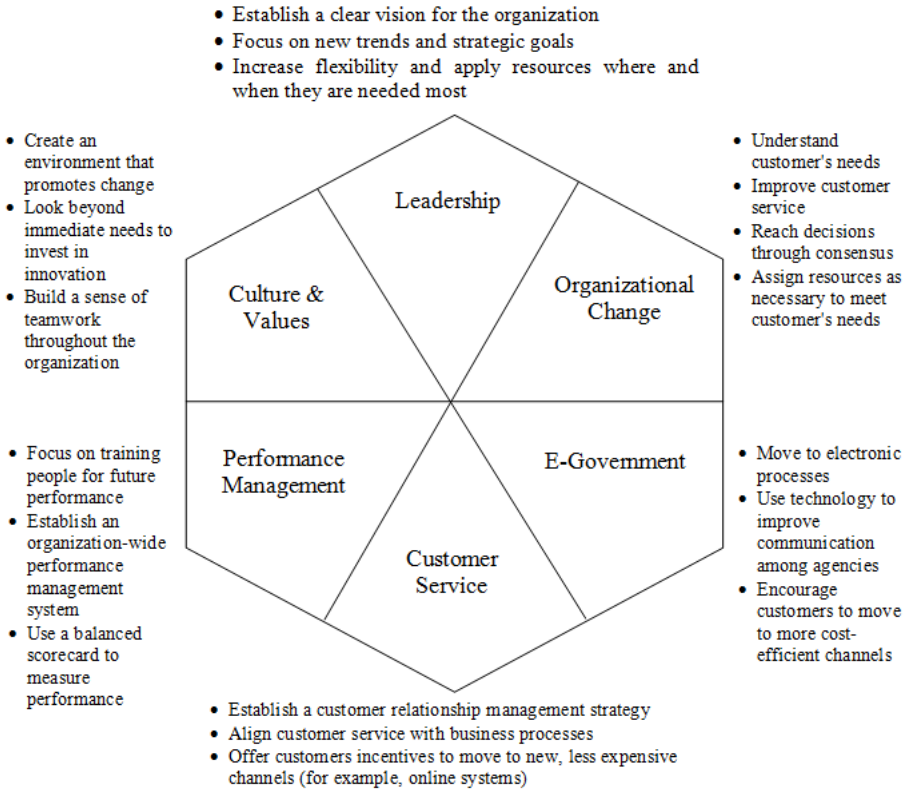
(1) Form a self-assessment committee, determine the required agility level and select agile- enabled attributes for assessment.
(2) Collect and survey data or information.
(3) Determine the appropriate preference scale for assessing the ratings and weights of the agile-enable-attributes.
(4) Measure the agile-enabled-attributes' ratings and weight using linguistic terms.
(5) Approximate the linguistic ratings and weights with fuzzy numbers.

[1]More than 50 agencies from the governments of Australia, Canada, France, Germany, Italy, New Zeland, the United Kingdom and the United States participated in the study.

(6) Aggregate fuzzy ratings and fuzzy weights into the FAI.
(7) Translate the FAI into an appropriate linguistic level.
(8) Analyze gaps and identify barriers to agility.

4.1. **Form a Self-assessment Committee, Determine the Required Agility Level and Select Agile-enable-attributes for Assessment.** For successful knowledge acquisition, various experts must be chosen from different departments. This approach not only ensures complete domain coverage, but also encourages that all areas of business will receive equal emphasis in the final system.

4.2. **Collecting Survey Data or Information.** To prepare for agility assessment, the assessors must survey and study the related data or information on agility implementation, focusing particularly on challenges in the business environment and on organization performance. The survey aims to understand the information that will be considered in assessing agility-enable-attributes.



Source: A. T. Kearney, 2003

FIGURE 1. The Model of Agile Government

4.3. **Preference Scale System.** Due to imprecise and ambiguous criteria in agility evaluation, a precision-based evaluation may be impractical. Thus assessments are frequently measured linguistically rather than numerically. Ad hoc usage of linguistic terms and the corresponding membership functions are characteristics of fuzzy logic. For convenience, linguistic terms and their membership functions as a substitute for assessor elicitation were obtained directly from previous studies, or were based on the needs of cognitive perspectives and available data characteristics used data from previous studies as a basis for modifying linguistic terms to meet individual situations and requirements.

4.4. **Aggregate Fuzzy Ratings and Weights into the FAI.** The operations in the set of fuzzy numbers are usually obtained by the Zadeh extension principle [9]. Many indices (e.g. arithmetic mean, median, and mode) have been propose for aggregating the assessments of multiple decision-makers. Since the average operation is the most widespread aggregation method, this study uses the arithmetic mean to pool the opinions of experts.

Assume that a committee of m evaluators, i.e., E_t; $t = 1, 2, ..., m$, conducts the agility evaluation and F_j, $j = 1, 2, ..., n$, are the factors for measuring agility. Suppose that R_{tj}= (a_{jt} , b_{jt} , c_{jt}) and W_{tj}= (x_{jt} , y_{jt} , z_{jt}) are fuzzy numbers respectively approximating the linguistic ratings and the linguistic importance weights assigned to F_t by assessor E_t. Then the average fuzzy rating R_j and average fuzzy weight W_j, the aggregation of the opinions of experts are calculated as:

$$R_j = (a_j, b_j, c_j) = (R_{j1}(+)R_{j2}(+)\dots(+)R_{jm})/m \tag{1}$$

$$W_j = (x_j, y_j, z_j) = (W_{j1}(+)W_{j2}(+)\dots(+)W_{jm})/m \tag{2}$$

The fuzzy agility index (FAI) is an information fusion, which consolidates the fuzzy ratings and fuzzy weights of all the factors that influence agility. FAI represents the overall agility of an organization. Agility increases with increasing FAI and the membership function of FAI is used to determine the agility level.

Let R_j and W_j,$j = 1; 2; ...; n$, respectively denote the average fuzzy rating and average fuzzy weight given by the evaluation committee to factor j. The fuzzy agility index FAI, then is defined as

$$FAI = \sum_{j=1}^{n}(W_j(.)R_j)/\sum_{j=1}^{n} W_j \tag{3}$$

The membership function of FAI can now be calculated using the fuzzy weighted average operation.

4.5. **Match the Fuzzy Attractiveness Rating with an Appropriate Linguistic Level.** To obtain the agility level, the FAI is matched with the linguistic label chosen from the natural-language expression set of agility so that its membership function is the same as (or closest to) the membership function of the FAI . label (AL).

Several methods have been proposed for matching the membership function with linguistic terms. These include (1) Euclidean distance, (2) successive approximation, and (3) piecewise decomposition. This study recommends utilizing the Euclidean distance method since it is the most intuitive method for humans to use for measuring proximity.

The Euclidean method calculates the Euclidean distance from the given fuzzy number to each of the fuzzy numbers representing the natural-language agility level expression set. Suppose that the natural-language agility level expression set is AL, and $U_{FAI}$and U_{ALi} represent the membership functions of the FAI and natural-language agility i, respectively. The distance between $U_{FAI}$and U_{ALi} is calculated as**:**

$$d(FAI, AL_i) = \{\sum_{x\varepsilon p}(U_{FAI}(x) - U_{Ali}(x))^2\}^{1/2} \tag{4}$$

Where p $=\{x_0, x_1, \ldots, x_m\} \subset [0\ ,\ 1]$ so that $0 = x_0 < x_1 < \ldots < x_m = 1.0$. To simplify, let p=$\{0, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1\}$.The distance from the FAI to natural-language agility i can then be calculated, and the closest natural expression with the smallest distance $U_{FAI}$to U_{ALi}can be identified.

4.6. **Rank Fuzzy Merit-importance Indexes of Agility Provider.** As mentioned above, agility evaluation not only determines agility, but also helps managers identify the main factors involved in implementing an appropriate action plan to improve the agility level.

To identify the main obstacles to improving the agility level, a fuzzy performance-importance index (FPII) is defined, which combines the performance rating and weighting of each agile- enable-attribute. FPII represents an effect which influences agility level and the degree of contribution of a factor to agility decreases with decreasing FPII. Thus, the FPII score of a factor is used to identify the principal obstacles to agility.

If used directly to calculate the FPII, the importance weights W_i will neutralize the performance ratings and it will become impossible to identify the actual main obstacles (low performance rating and high importance). If W_i is high, then the transformation [(1,1,1) (-) W_i] is low. Consequently, to elicit a factor with low performance rating and high importance, for each agile-enable-attribute i, the fuzzy performance- importance index $FPII_i$, indicating the effect of each agile-enable-attribute that contributes to agility, is defined as:

$$FMII_i = R_i(.)[(1, 1, 1)(-)W_i] \tag{5}$$

Unlike real numbers, fuzzy numbers do not always yield a totally ordered set and hence several methods have been proposed for ranking them. Here, the FPII are ranked based on the left-and-right fuzzy-ranking method of Chen and Hwang [4], since this method not only preserves the ranking order but also considers the absolute location of each fuzzy number. The disadvantage of this method is that the ranking score will be different when different fuzzy maximizing and minimizing sets are used.

The fuzzy maximizing and minimizing sets are, respectively, defined as:

$$U_{max}(x) = \begin{cases} x & ,0 \leq x \leq 1, \\ 0 & ,\text{otherwise.} \end{cases} \tag{6}$$

$$U_{min}(x) = \begin{cases} 1-x & ,0 \leq x \leq 1, \\ 0 & ,\text{otherwise.} \end{cases} \tag{7}$$

Given a triangular fuzzy number FPII defined by $U_{FPII} : R \rightarrow [0 , 1]$, the right-and-left scores of FPII can be obtained, respectively, as:

$$U_R(FPII) = \sup [U_{FPII}(x) \hat{} U_{max}(x)] \tag{8}$$

$$U_L(FPII) = \sup [U_{FPII}(x) \hat{} U_{min}(x)] \tag{9}$$

Where $\hat{}$ denotes the Min operator. Finally, the total score can be calculated by combining the left-and-right scores as follows:

$$U_T(FPII) = [U_R(FPII) + 1 - U_L(FPII)] / 2 \tag{10}$$

5. **Case Study**

This section discusses the agility evaluation of a General Office of Standards & Industrial Research of Sistan & Baluchestan Province in Iran to demonstrate that the FAEM procedure can be applied to measure agility in the public sector.

5.1. **Measuring Agility Using Fuzzy Logic.** Owing to ill-defined and ambiguous agile-enable attributes, conventional assessment approaches are ineffective for their measurement and hence most measures are described subjectively using linguistic terms. The assessors endeavored to apply a fuzzy logic approach in their assessment. To achieve a large-scale global and extremely agile organization, the following agility evaluation procedure was used:

Step 1: Identify the agile-enabling attributes:

The first task in successfully analyzing and measuring agility is to identify agility-enablers. To accurately elicit assessment criteria that reflect the complete set of attributes of an agile organization, we use methods described in the literature and the A.T.Kearney model to determine the hierarchical AA structure listed in Table 1.

Step 2: Devise preference evaluation terms:

Since the needs of cognitive perspectives, the available data characteristics and differences in learning or experience connect assessment terms, managers were initially unable to reach a consensus. For convenience, the linguistic terms and corresponding membership functions used in previous studies were adopted as a basis of evaluation terms. Finally, the rating scale (i.e., Worst [W], Very Poor [VP], Poor [P], Fair [F], Good [G], Very Good [VG], Excellent [E]) was used to measure the

Main Attributes	**Index**	**Sub-Attributes**	**Index**
leadership	AA_1	Establishment of a clear vision for the organization	AA_{11}
		Focusing on new trends and strategic goals	AA_{12}
		Using resources for strategic goals	AA_{13}
		Assuring implementation of organizational change plans	AA_{14}
Culture and values	AA_2	Organizational flexibility for restructuring	AA_{21}
		Decision Making based on consensus	AA_{22}
		Readiness for change in organization	AA_{23}
		Employee access to needful knowledge	AA_{24}
		Characterizing the goals and premiums of team working	AA_{25}
		The amount of centralization in organization	AA_{26}
		Ability of decision making by employees	AA_{27}
Customer Service	AA_3	Existing strategies for management in relation with customers	AA_{31}
		Access to managers by the customers	AA_{32}
		Instruction of employees about relationship with customers	AA_{33}
		Work evaluation about customer	AA_{34}
		The amount of management involvement with customers	AA_{35}
E-Government	AA_4	The amount of acceptance of new technologies	AA_{41}
		Setting needful information in web site	AA_{42}
		Possibility of E-Consultation for customers	AA_{43}
		Emphasis on inputs of citizens for decision making	AA_{44}
		Incentives for shifting customers to low cost channels	AA_{45}
Performance Management	AA_5	Existence of continuum work evaluation system	AA_{51}
		Adjustment and centralization on priorities	AA_{52}
		Producing adequate and on time services to customers	AA_{53}
		Instruction people for future works	AA_{54}
Organizational Change	AA_6	Existence of comprehensive method for realization of customer's prospect	AA_{61}
		Identifying opportunities and needs for improvement of processes	AA_{62}
		Existence of comprehensive system for transforming customer needs to services	AA_{63}
		Renovation in organization	AA_{64}
		Implementation of new technologies in producing services	AA_{65}

Table 1. Agility Attributes for Measuring Agility Index

ratings of the agile-enable-attributes and the weighting scale (i.e., Very Low [VL], Low [L], Fairly Low [FL], Medium [M], Fairly High [FH], High [H], Very High [VH]) was used to measure the weighting of agile-enable-attributes. Furthermore, based on its longstanding recognition of the meaning of linguistic value the fuzzy numbers listed in Table 2 were selected to approximate linguistic ratings and weights for performance and importance, respectively.

Performance ratings			**Importance weights**		
Linguistic variables	*Symbol*	*Fuzzy numbers*	*Linguistic variables*	*Symbol*	*Fuzzy numbers*
Worst	W	*(0,0.05,0.15)*	Very Low	*VL*	(0,0.05,0.15)
Very Poor	VP	*(0.1,0.2,0.3)*	Low	*L*	(0.1,0.2,0.3)
Poor	P	*(0.2,0.35,0.5)*	Fairly Low	*FL*	(0.2,0.35,0.5)
Fair	F	*(0.3,0.5,0.7)*	Medium	*M*	(0.3,0.5,0.7)
Good	G	*(0.5,0.65,0.8)*	Fairly High	*FH*	(0.5,0.65,0.8)
Very Good	VG	*(0.7,0.8,0.9)*	High	*H*	(0.7,0.8,0.9)
Excellent	E	*(0.85,0.95,1.0)*	Very High	*VH*	(0.85,0.95,1.0)

Table 2. Linguistic Variables and Their Corresponding Fuzzy Numbers for Assessing

Step 3: Measure the agile-enable-attributes using linguistic terms, and approximate the linguistic terms using fuzzy numbers:

Based on the collected data and their personal experience/knowledge, experts applied the rating terms to assess the performance of the different criteria and to evaluate the relative importance of both the main criteria and the sub-criteria. The results are listed in Table 3. Also, based on the corresponding relation between the linguistic terms and fuzzy numbers listed in Table 2, the linguistic terms of rating and weight were approximated with fuzzy numbers.

Step 4: Aggregate the fuzzy ratings and fuzzy weights into a FAI:

Equations (1) and (2) can be used to aggregate the rating and weight fuzzy numbers under the same criterion (Notice: All calculations were calculated with designed program in MATLAB software).

Table 4 lists average fuzzy ratings and average fuzzy weights of main criteria AA_i and sub-criteria AA_{ij}.

Using equation (3), the integrated fuzzy ratings were obtained as:

AA_1= (0.5854, 0.7163, 0.8297),
AA_2 = (0.5249, 0.6526, 0.7713),
AA_3 = (0.6731, 0.7896, 0.8846),
AA_4 = (0.5161, 0.6419, 0.7506),
AA_5 = (0.6766, 0.7935, 0.8851),
AA_6 = (0.5483, 0.6852, 0.8120).

Finally, applying equation (3) again, the FAI of the organization was obtained as (For more details see Appendix A):

FAI = (0.5871, 0.7128, 0.8217).

$\mathbf{AA}_i$	$\mathbf{AA}_{ij}$	**Ratings of sub- criteria assigned by assessors using linguistic terms**					**Weights of main criteria and sub-criteria assigned by assessors using linguistic terms**				
		$\mathbf{E}_1$	$\mathbf{E}_2$	$\mathbf{E}_3$	$\mathbf{E}_4$	$\mathbf{E}_5$	$\mathbf{E}_1$	$\mathbf{E}_2$	$\mathbf{E}_3$	$\mathbf{E}_4$	$\mathbf{E}_5$
$\mathbf{AA}_1$							FH	VH	H	VH	M
	$\mathbf{AA}_{11}$	F	E	VG	VG	F	VH	VH	H	VH	H
	$\mathbf{AA}_{12}$	F	E	VG	E	F	VG	VH	H	H	FH
	$\mathbf{AA}_{13}$	VP	E	VG	E	F	VH	H	H	FH	VH
	$\mathbf{AA}_{14}$	P	E	VG	E	G	FL	H	VH	H	FH
$\mathbf{AA}_2$							VH	VH	FH	FH	FH
	AA_{21}	F	E	VG	G	P	M	H	VH	FH	F
	AA_{22}	P	E	E	G	P	VH	H	FH	FH	H
	AA_{23}	F	E	VG	G	P	FL	H	L	VH	M
	AA_{24}	P	E	VG	VG	G	H	H	H	VH	FH
	AA_{25}	VP	VG	E	G	F	VH	H	VH	FH	H
	AA_{26}	VG	W	VG	VG	F	M	VL	VH	FH	M
	AA_{27}	P	E	VG	VG	F	H	L	H	VH	H
$\mathbf{AA}_3$							VH	H	FH	FH	H
	$\mathbf{AA}_{31}$	VG	E	E	E	G	H	VH	VH	VH	FH
	$\mathbf{AA}_{32}$	F	E	E	E	VG	FH	M	VH	H	H
	$\mathbf{AA}_{33}$	F	E	E	G	G	VH	M	VH	H	M
	$\mathbf{AA}_{34}$	VP	E	VG	E	G	VH	FH	VH	H	M
	$\mathbf{AA}_{35}$	VG	VG	VG	E	G	VH	FL	H	VH	FH
$\mathbf{AA}_4$							VH	VH	VH	H	H
	$\mathbf{AA}_{41}$	VG	E	E	E	P	H	H	VH	VH	H
	$\mathbf{AA}_{42}$	VP	E	P	VG	P	VH	VH	VH	H	VH
	$\mathbf{AA}_{43}$	VP	E	P	VG	P	VH	FH	VH	H	VH
	$\mathbf{AA}_{44}$	F	E	E	G	F	VH	H	H	FH	VH
	$\mathbf{AA}_{45}$	VP	E	E	F	G	VH	VH	VH	M	H
$\mathbf{AA}_5$							FH	VH	VH	VH	FH
	$\mathbf{AA}_{51}$	P	E	E	E	G	H	VH	VH	VH	FH
	$\mathbf{AA}_{52}$	F	E	VG	VG	G	VH	FH	H	H	FH
	$\mathbf{AA}_{53}$	VG	E	E	E	VG	VH	FH	VH	VH	H
	$\mathbf{AA}_{54}$	P	E	E	G	E	VH	VH	VH	VH	H
$\mathbf{AA}_6$							FL	H	VH	M	VH
	$\mathbf{AA}_{61}$	P	E	VG	E	VG	M	H	H	VH	H
	$\mathbf{AA}_{62}$	P	E	VG	VG	F	FH	H	H	H	FH
	$\mathbf{AA}_{63}$	P	VG	VG	G	G	FH	VH	E	H	H
	$\mathbf{AA}_{64}$	F	VG	G	G	F	FH	VH	VH	VH	G
	$\mathbf{AA}_{65}$	F	E	G	E	F	H	VH	VH	VH	H

TABLE 3. Ratings and Weights of Main Criteria and Sub-criteria Assigned by Assessors Using Linguistic Terms

Step 5: The FAI is translated into an appropriate linguistic term.

After obtaining the FAI, to identify the agility level, the assessments further approximated a linguistic label with a meaning identical or close to the meaning of the FAI from the natural- language expression set of the agility level (AL). In

AA_i	AA_{ij}	Fuzzy average rating	Fuzzy average weights
AA_1			(0.64,0.77,0.88)
	AA_{11}	(0.57,0.71,0.84)	(0.79,0.89,0.96)
	AA_{12}	(0.60,0.74,0.86)	(0.69,0.80,0.90)
	AA_{13}	(0.56,0.68,0.70)	(0.72,0.83,0.92)
	AA_{14}	(0.62,0.74,0.84)	(0.59,0.71,0.82)
AA_2			(0.64,0.77,0.88)
	AA_{21}	(0.51,0.65,0.78)	(0.53,0.86,0.82)
	AA_{22}	(0.52,0.65,0.76)	(0.65,0.77,0.88)
	AA_{23}	(0.51,0.65,0.78)	(0.43,0.56,0.68)
	AA_{24}	(0.59,0.71,0.82)	(0.69,0.80,0.90)
	AA_{25}	(0.49,0.62,0.74)	(0.72,0.83,0.92)
	AA_{26}	(0.48,0.59,0.71)	(0.39,0.53,0.67)
	AA_{27}	(0.55,0.86,0.80)	(0.61,0.71,0.80)
AA_3			(0.65,0.77,0.88)
	AA_{31}	(0.75,0.86,0.94)	(0.75,0.86,0.94)
	AA_{32}	(0.71,0.83,0.92)	(0.61,0.74,0.86)
	AA_{33}	(0.60,0.74,0.86)	(0.60,0.74,0.86)
	AA_{34}	(0.60,0.71,0.80)	(0.64,0.77,0.88)
	AA_{35}	(0.69,0.80,0.90)	(0.62,0.74,0.84)
AA_4			(0.79,0.89,0.96)
	AA_{41}	(0.76,0.86,0.94)	(0.76,0.86,0.94)
	AA_{42}	(0.82,0.92,0.98)	(0.82,0.92,0.98)
	AA_{43}	(0.75,0.86,0.94)	(0.75,0.86,0.94)
	AA_{44}	(0.72,0.83,0.92)	(0.72,0.83,0.92)
	AA_{45}	(0.52,0.65,0.76)	(0.71,0.83,0.92)
AA_5			(0.71,0.83,0.92)
	AA_{51}	(0.65,0.77,0.86)	(0.75,0.86,0.94)
	AA_{52}	(0.61,0.74,0.86)	(0.65,0.77,0.88)
	AA_{53}	(0.79,0.89,0.96)	(0.75,0.86,0.94)
	AA_{54}	(0.65,0.77,0.86)	(0.82,0.92,0.98)
AA_6			(0.58,0.71,0.82)
	AA_{61}	(0.66,0.77,0.86)	(0.65,0.77,0.88)
	AA_{62}	(0.55,0.68,0.80)	(0.62,0.74,0.86)
	AA_{63}	(0.52,0.65,0.78)	(0.72,0.83,0.92)
	AA_{64}	(0.46,0.62,0.78)	(0.71,0.83,0.92)
	AA_{65}	(0.56,0.71,0.84)	(0.79,0.89,0.96)

TABLE 4. Average Fuzzy Ratings and Average Fuzzy Weights of Main Criteria and Sub-criteria

this case, the agility level set AL was {Definitely Agile [DA], Extremely Agile [EA], Very Agile [VA], Highly Agile [HA], Agile [A], Fairly [F], Slightly Agile [SA], Low Agile [LA], Slowly [S]}, The linguistics and corresponding membership functions are shown in Figure 2 and Table 5.

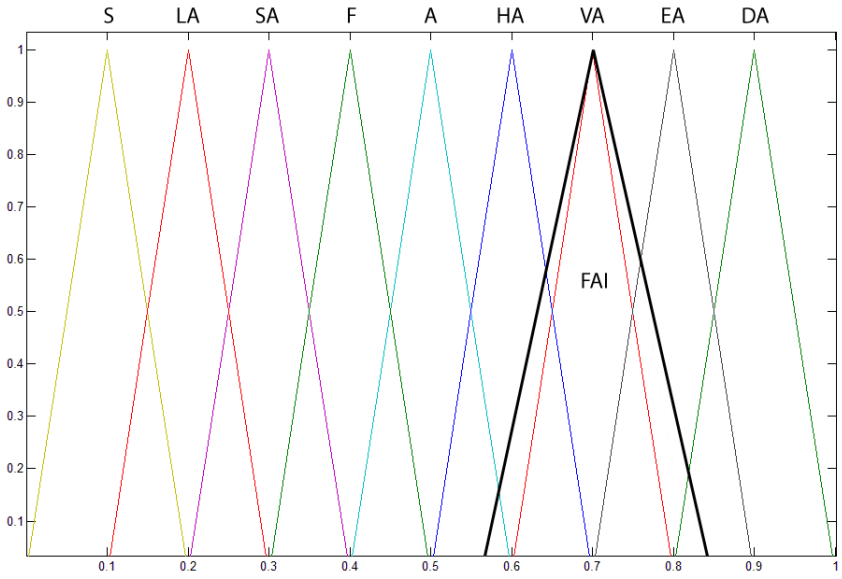


FIGURE 2. Linguistic Levels for Matching the FAI

Symbol	**Linguistic variables**	**Fuzzy numbers**
DA	*Definitely Agile*	(0.8 , 0.9 , 1.0)
EA	*Extremely Agile*	(0.7 , 0.8 , 0.9)
VA	*Very Agile*	(0.6 , 0.7 , 0.8)
HA	*Highly Agile*	(0.5 , 0.6 , 0.7)
A	*Agile*	(0.4 , 0.5 , 0.6)
FR	*Fairly*	(0.3 , 0.4 , 0.5)
SA	*Slightly Agile*	(0.2 , 0.3 , 0.4)
LA	*Low Agile*	(0.1 , 0.2 , 0.3)
S	*Slowly*	(0.0 , 0.1 , 0.2)

TABLE 5. Average Fuzzy Ratings and Average Fuzzy Weights of Main Criteria and Sub-criteria

Equation (4) was then used to calculate the Euclidean distance d from the FAI to each member in set AL:

d (FAI , DA) = 0.3349 d (FAI , EA) = 0.1627
d (FAI , VA) = 0.0283 d (FAI , HA) = 0.1874
d (FAI , A) = 0.3598 d (FAI , FR) = 0.5327
d (FAI , SA) = 0.7057 d (FAI , LA) = 0.8789
d (FAI , S) = 1.0520

Thus, by matching a linguistic label with the minimum d, the General Office of Standards & Industrial Research of Sistan & Baluchistan Province can be labeled "Very Agile".

Step 6: Perform gap analysis and identify the barriers to agility:

The agility index of the General Office of Standards & Industrial Research of Sistan & Baluchistan Province approaches "Very Agile" (according to the evaluation) but is far from "Extremely Agile" (the agility level required by General Office of Standards & Industrial Research of Sistan & Baluchistan Province). Clearly, obstacles exist within the organization that block agility achievement. Equation (5) helps us obtain the 30 FPIIs of the agile-enable-attributes, as listed in Table 6.

Sub-Attributes	**Fuzzy merit-importance indexes**	**Ranking score**
AA_{11}	(0.0228 , 0.0781 , 0.1764)	0.0927
AA_{12}	(0.0600 , 0.1480 , 0.2666)	0.1590
AA_{13}	(0.0448 , 0.1156 , 0.2184)	0.1280
AA_{14}	(0.1116 , 0.2146 , 0.3444)	0.2226
AA_{21}	(0.0918 , 0.2080 , 0.3666)	0.2226
AA_{22}	(0.0624 , 0.1495 , 0.2660)	0.1596
AA_{23}	(0.1632 , 0.2860 , 0.4446)	0.2974
AA_{24}	(0.0590 , 0.1420 , 0.2542)	0.1516
AA_{25}	(0.0392 , 0.1054 , 0.2072)	0.1158
AA_{26}	(0.1584 , 0.2773 , 0.4331)	0.2906
AA_{27}	(0.1100 , 0.1972 , 0.3120)	0.2070
AA_{31}	(0.0450 , 0.1204 , 0.2350)	0.1349
AA_{32}	(0.0994 , 0.2158 , 0.3588)	0.2261
AA_{33}	(0.0840 , 0.1924 , 0.3440)	0.2057
AA_{34}	(0.0720 , 0.1633 , 0.2880)	0.1732
AA_{35}	(0.1104 , 0.2080 , 0.3420)	0.2195
AA_{41}	(0.0414 , 0.1120 , 0.2112)	0.1214
AA_{42}	(0.0082 , 0.0424 , 0.1152)	0.0595
AA_{43}	(0.0246 , 0.0742 , 0.1600)	0.0851
AA_{44}	(0.0448 , 0.1207 , 0.2352)	0.1349
AA_{45}	(0.0416 , 0.1105 , 0.2204)	0.1248
AA_{51}	(0.0390 , 0.1078 , 0.2150)	0.1203
AA_{52}	(0.0732 , 0.1702 , 0.3010)	0.1790
AA_{53}	(0.0474 , 0.1246 , 0.2400)	0.1391
AA_{54}	(0.0130 , 0.0616 , 0.1548)	0.0747
AA_{61}	(0.0792 , 0.1771 , 0.3010)	0.1834
AA_{62}	(0.0770 , 0.1768 , 0.3040)	0.1842
AA_{63}	(0.0416 , 0.1105 , 0.2184)	0.1240
AA_{64}	(0.0368 , 0.1054 , 0.2262)	0.1222
AA_{65}	(0.0224 , 0.0781 , 0.1764)	0.0926

TABLE 6. Fuzzy Merit-importance Indexes of Sub-criteria

Finally, equations (6)–(10) were applied to defuzzify the FPIIs, as in Table 6. The scores represent the effect of each agile-enabler which contributes to agility. Based on the Pareto principle [5], the experts focused resources on the critical few factors (10%) and set a scale of 0.10 as the management threshold for identifying the factors requiring most urgent improvement. Table 6 indicates that five factors performed below the threshold, namely: (1) Clear Vision for organization, (2) Setting needful information on the web site, (3) Possibility of E-Consultation for customers, (4) Instruction of people for future works, (5) Implementation of new technologies in producing services.

These factors make the most significant contributions to enhancing agility. Combined with the weakest factors within the organization, these factors indicate that an action plan be conducted to improve the adverse factors and enhance organization agility.

6. **Conclusion**

Agility is the ability of an organization to adapt to change and also to seize opportunities that become available due to change. And in government, agility means understanding and meeting the needs of citizens in the short term, adapting structures and services to address medium term trends, and shaping needs in the long term.

Based on the results of this paper , we submit five solutions for increasing the agility level of the General Office of Standards & Industrial Research of Sistan & Baluchestan Province. The key to increasing organizational agility in this organization lies in improving the following attributes:
1- Clear Vision for organization, 2- Setting needful information in web site, 3- Possibility of E-Consultation for customers, 4- Instruction people for future works, 5- Implementation of new technologies in producing services.

7. **Appendix A**

In this section of the paper, we give an example of the calculations performed to obtain the Fuzzy Agility Index (FAI). First, using equality (1), we have:

$$R_j = (a_j\ ,\ b_j\ ,\ c_j) = (R_{j1}(+)R_{j2}(+)\ \ldots\ (+)R_{jm})\ /\ m \tag{1}$$

AA_{11} = (F+E+VG+VG+F)/5 = (0.5700, 0.7100, 0.8400),
AA_{12} = (F+E+VG+E+F)/5 = (0.6000, 0.7400, 0.8600),
AA_{13} = (VP+E+VG+E+F)/5 = (0.5600, 0.6800, 0.7800),
AA_{14} = (P+E+VG+E+G)/5 = (0.6200, 0.7400, 0.8400).

Now, from equation (2), we obtain the following Fuzzy Agility Weights:

$$W_j = (x_j\ ,\ y_j\ ,\ z_j) = (W_{j1}(+)W_{j2}(+)\ \ldots\ (+)W_{jm})\ /\ m \tag{2}$$

FAW_{11} = (VH+VH+H+VH+H)/5 = (0.7900, 0.8900, 0.9600),
FAW_{12} = (VG+VH+H+H+FH)/5 = (0.6900, 0.8000, 0.9000),
FAW_{13} = (VH+H+H+FH+VH)/5 = (0.7200, 0.8300, 0.9200),
FAW_{14} = (FL+H+VH+H+FH)/5 = (0.5900, 0.7100, 0.8200),

WAA_1 = (FH+VH+H+VH+M)/5 = (0.6400, 0.7700, 0.8800).

The other agile attributes are calculated similarly(see Table 4). Furthermore, using equation (3), the integrated fuzzy ratings are obtained as:

$$FAI = \sum_{j=1}^{n}(W_j\ (.)\ R_j)\ /\ \sum_{j=1}^{n} W_j \tag{3}$$

AA_1 = (AA_{11} FAW_{11}) + (AA_{12} FAW_{12}) + (AA_{13} FAW_{13}) + (AA_{14} FAW_{14}) / (FAW_{11} + FAW_{12} + FAW_{13} + FAW_{14}),
Thus, Agility Attribute 1 (AA_1) = (0.5854, 0.7163, 0.8297).

Similarly, AA_2 = (0.5249, 0.6526, 0.7713),
AA_3 = (0.6731, 0.7896, 0.8846),
AA_4 = (0.5161, 0.6419, 0.7506),
AA_5 = (0.6766, 0.7935, 0.8851),
AA_6 = (0.5483, 0.6852, 0.8120).

Finally, applying equation (3) again, the FAI of the organization is obtained as:

WAA_1 = (FH+VH+H+VH+M)/5 = (0.6400, 0.7700, 0.8800),
WAA_2 = (VH+VH+FH+FH+FH)/5 = (0.6400, 0.7700, 0.8800),
WAA_3 = (VH+H+FH+FH+H)/5 = (0.6500, 0.7700, 0.8800),
WAA_4 = (VH+VH+VH+H+H)/5 = (0.7900, 0.8900, 0.9600),
WAA_5 = (FH+VH+VH+VH+FH)/5 = (0.7100, 0.8300, 0.9200),
WAA_6 = (FL+H+VH+M+VH)/5 = (0.5800, 0.7100, 0.8200).

Thereby,

FAI = [(AA_1WAA_1) + (AA_2WAA_2) + (AA_3WAA_3) + (AA_4WAA_4) + (AA_5WAA_5) + (AA_6WAA_6)] / (WAA_1 + WAA_2 + WAA_3 + WAA_4 + WAA_5 + WAA_6) = (0.5871, 0.7128, 0.8217).

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