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MEASURING AGILITY OF INDIAN AUTOMOTIVE SMALL & MEDIUM SIZED ENTERPRISES (SMEs)

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ABSTRACT
Indian SMEs are going to play pivotal role in transforming Indian economy and achieving double digit growth rate in near future. Performance of Indian SMEs is vital in making India as a most preferred manufacturing destination worldwide under India's "Make in India Policy". Current research was based on Indian automotive SMEs. Indian automotive SMEs must develop significant agile capability in order to remain competitive in highly uncertain global environment. One of the objectives of the research was to find various enablers of agility through literature survey. Thereafter questionnaire administered exploratory factor analysis was performed to extract various factors of agility relevant in Indian automotive SMEs environment. Multiple regression analysis was applied to assess the relative importance of these extracted factors. "Responsiveness" was the most important factor followed by "Ability to reconfigure", "Ability to collaborate", and "Competency". Thereafter fuzzy logic bases algorithm was applied to assess the current level of agility of Indian automotive SMEs. It was found as "Slightly Agile", which was the deviation from the targeted level of agility. Fuzzy ranking methodology facilitated the identification & criticalities of various barriers to agility, so that necessary measures can be taken to improve the current agility level of Indian automotive SMEs. The current research may helpful in finding; key enablers of agility, assessing the level of agility, and ranking of the various enablers of agility to point out the weak zone of agility so that subsequent corrective action may be taken in any industrial environment similar to India automotive SMEs.

KEYWORDS
exploratory factor analysis, multiple regression analysis, fuzzy logic, fuzzy integrated index (FII) & fuzzy performance index (FPII), fuzzy ranking.

Introduction

After World War II there were significant changes in global business environment. Global economies are well integrated and moved from closed economy to open economy. No single organization can enjoy monopoly and it's a migration from monopolistic to oligopolistic/fragmented market that changed the face of competition. Therefore, the traditional way of doing business is no longer guarantee you success. Philosophy of mass production has become obsolete and replaced by mass customization. Customers' demand is fast changing, which led to a shrinkage of product life cycle. The changes are increasingly becoming unpredictable. These unprecedented changes resulted in major shift in business priorities and strategic intent of the organizations [1]. Now the organizations need to respond appropriately to these changes, termed as business agility. The term agility was first formally put forth by Iacocca Institute in 1991.

Being a member of world trade organization, India is a part of well integrated global economy. Therefore, Indian manufacturing segment is not immune to the global changes taking place. India has a potential to become global manufacturing hub and ac-

cording to an estimate India is likely to surpass China as a most preferred manufacturing destination by 2050. Indian SMEs constitute significant part of the manufacturing sector. Therefor Indian SMEs must increase their adaptability by responding appropriately to the changes in the business environment. They must strive to become agile like never before to acquire sustainable strategic edge over others to beat the impending global competition. For the current research a special segment of SMEs that is Indian automotive industry was chosen [2].

The objectives of current research are to identify various enablers of agility, measure the current status of level of agility, and key barriers to agility in Indian automotive industry. Total 27 enablers of agility were found through the literature review. Questionnaire administered survey was used to gather information about the relevance and importance of various enablers of agility. Exploratory survey and thereafter multiple regression analysis was applied to assess relative importance of extracted factors. Statistical analysis suggested exploratory factor analysis & multiple regression analysis were the appropriate techniques for the current research. Due to the amount of vagueness & subjectivity involved in the current research the application of quantitative dependency techniques such as multiple regression has found its own sets of limitation, thus findings may prone to error & difficult generalized. Extensive literature survey was conducted to find the appropriate technique for the decision making, where the subjectivity in involved. Fuzzy logic based multi criteria decision making methodology was found to be the appropriate in the given circumstance. Fuzzy logic algorithm having comprehensive methodology to measure agility and left & right fuzzy ranking procedure ensured the unbiased ranking of various enablers of agility [3].

Literature review

Manufacturing In the era of increasingly fickle business environment, organization across the globe must match to it by becoming dynamic like never before by complying with the changes in both in internal and external environment [1]. Manufacturing agility is the perfect blend of organization capability & Industry characteristics. Manufacturing agility is its capacity to endure and thrive in a business environment which is continuously changing hence become unpredictable [2]. Agility is the organizational capability to respond appropriately to the different kinds of changes. Thus agility impart substantial strategic advantage to remain competitive in open economy [4].

Modelling Agility

Different models of organizational agility were proposed over the years by different researchers worldwide. The earliest known preliminary model of agility was proposed by Goldman since inception of word agility in the industrial word in 1990. Model described four key measures of agility namely: Enhancing the customer satisfaction, Co-operation and collaboration to tackle uncertain business environment, enhancing the skills of the people and exploitation of information technology to enhance the competitiveness of the organization, and develop ability to control changes in the external environment [5].

Sharifi & Zhang proposed a detailed frame work of agility with the objectives of describing its prime component namely: Agility Drivers, Agility Capabilities, and Agility Providers. Drivers are basically unexpected changes in the business environment. Agility capabilities mean organizational capability to respond appropriately and timely to these changes in the environment. Providers are the facilitator which help the organization to achieve agility [6].

A comprehensive model of agile enterprise was proposed by Lin et al. build on the foundation of leveraging the knowledge from people and information technology, exercising proper control by mastering change and uncertainty, and supported by proper strategy through collaborative relationship [3].

It is very difficult for a organization to possess all the resources to excel, thrive and beat the competition, therefore must learn to collaborate. Ability to collaborate with the suppliers and the customers resulted in value chain optimization and significant reduction in the cost of production [7]. The typical activities of ability to collaborate were maintaining close relationship with the suppliers, strategic relationship with the suppliers, suppliers managed inventory system, and supplier & customer participation in process & product design resulted in value chain optimization, continuous improvement in the quality, and significant reduction in the cost of production. These activities not only increases the competitiveness of the organization but also help in knowing customer requirements and impart significant agility to your organization [8].

Proper risk identification and management system in place helps in measuring the impending risk and makes you proactive by bringing about the necessary changes in the system with the help of cross functional team, flexible people, organization, layout, and machining system [9]. These activities helps in identification of change in market place and customers taste and developing appropriate measures

to increase your competitiveness and responsiveness [10].

Rapid prototyping, concurrent engineering, single minute exchange of dies, short new product development time, Short lean time to introduce new product to market, total productive maintenance, information integration between all bits and pieces of value chain, and process integration helps in matching up increasing fickle customer demand both in terms of variety & volume [11].

Manufacturing agility evaluation system

Change proficiency metrics was proposed to assess agility based on four parameters namely: strength, cost, space, and time. As the agility level increases the efforts required to change decreases and at ideal level of agility the change will be spontaneous at no cost. However the model is subjective in nature having vagueness in measuring agility [12]. A similar model was proposed by analyzing various process in different environment using three dimensions of measures of agility. The three dimensions were time to change, ease of change, and range of change. Lower is the extent of changes (range) in short period of time with relative ease, resulted in the higher agility of the organizations [13].

Indirect approach to measure agility was proposed by using complexity within enterprise and processes as proxy to agility. Hypothesis was formulated suggesting less complexity in the system and process it is comparatively easier for the enterprise to manage changes and hence become more agile. Model defined need of resources in processing and the interdependency of these resources as a dimension to measure the complexities [14]. Model involved too much of subjectivity in evaluation of enterprise complexities and turning to agility.

Step based approach to measure agility was proposed comprises of three steps. First was to understand the market, second was to determine strategic objectives, and finally the analysis of capability needed to achieve agility [15]. However the model again lack objectivity

Analytical hierarchical process was applied to evaluate the agility of the organization. Wherein the experts were asked to do the pairwise comparison to evaluate relative importance of various agile capabilities. Consolidation of judgement of agile capabilities facilitate the computation of agility of the entire organization. AHP based measurement certainly offered better results in comparison to direct ratio method [16].

Model so far discussed are relatively straight forward and hence easier to implement. However the

vagueness in describing agile capabilities often led to sub optimum results. Linguistic terms may be used for evaluation which result in less ambiguity and inconsistency in evaluation. Application of fuzzy logic based methodology of agility evaluation could be appropriate choice which enables mapping of linguistic assessment into fuzzy numbers.

Fuzzy logic based agility assessment models were also proposed. These models were based on applying IF-THEN rule. The central point of the approach was that it combined all infrastructure related parameters known as agile characteristics such as production, market, people, and information to their matching operational parameter in order to evaluate the agility. IF-THEN is a conditional statement used in mathematical reasoning. It associate observations (IF) with the value of agility. But the methodology of agility measurement based on fuzzy logic has to be reformulated in different context. Apart from this model is too complex to apply [17].

Fuzzy logic methodology with multi grade was presented to assess the agile capability of the organization where mass customization is possible. The proposed model applies the matrices obtained from the ratings given by the experts using relative weighing process for the various agility enablers. Model is comparatively easier to use and did use the fuzzification of the subjective evaluation. However the model often criticized for being not taking care of external factors into account [18].

Another model was proposed taking into the consideration both quantitative (tangible) & qualitative (intangible) elements and different criteria using fuzzy logic based algorithm of association rule mining to facilitate flexible decision making. Model suggested is highly complex in nature and methodology suggested equal weight for all the attributes which could results in sub optimum evaluation of agility [19].

Fuzzy logic association rule mining was presented to model and enhance the flexibility and agility of the supply chain [20].

Fuzzy logic based interpretive modelling was used to design frame work of supply chain and to enhance the visibility, flexibility, and agility of supply chain of the Indian SMEs [21].

Criteria bases fuzzy logic algorithm was applied to develop index of agility and to identify the key barriers to the agility for the organizations [22].

Fuzzy logic based approach for the development of index of agility for manufacturing organization was applied, where certain degree vagueness of data exists [23].

Fuzzy logic based algorithm was applied to measure the level of agility of Iranian television industry [24].

Fuzzy quality functional deployment was suggested to enhance the agile capabilities of the organizations [25].

Lin & associates presented a comprehensive fuzzy logic based agility evaluation system, which originally meant for supply chain agility evaluation. Model also used multi criteria decision making. Thus the whole model is well capable of not only in agility evaluation but also identifies the major barriers to agility, thus helps in improving the agility of the organization. Model suggested the fuzzy agility index (FAI) to let you know about the agility level of the organization. FAI is evaluated taking weighted average of performance in relation to the elements of agility and comparative importance of the elements of agility under consideration. After the evaluation of FAI it can be compared with the evaluation grade to assign linguistic term or numerical value. Model suggested one more index and called it fuzzy performance index (FPI) to identify major barriers to agility [3]. Model is comprehensive in nature and found its well proven applicability in variety of organizations including services and manufacturing.

Problem description

Research problem can be classified into two categories:

- Customization of various enablers of agility found through the literature survey for the Indian automotive industry with the help of questionnaire administered survey and exploratory factor analysis.
- Determination of current state of agility of Indian automotive industry and major barriers to agility applying suitable fuzzy logic based methodology.

Research methodology

Every organization got its own set of weaknesses and strengths. So it is difficult to develop a model fit for all organizations, irrespective of its size and industrial segment in which they operate. Therefore the need of an hour to develop customize model which is organizational specific in nature. The research started with the data gathering to know about the organizational specific agile capabilities and agility enablers to execute those capabilities.

The sample frame comprises of the front line managers working in Indian automotive industry, having fair idea of overall picture of their organization. Mostly the automotive industry in Delhi NCR, MIDC area, Chennai, and Tata Nagar were target-ed. Most of them are ancillary & suppliers of auto giant like Tata Motors, Maruti Suzuki, Mahendra & Mahendra, Hero Motors, Hyundai Motors, Honda Motors, and Suzuki Motors. The sample size was around 166. The sampling procedure was convenient sampling due to the fact, the amount of expertise and information required pertaining to the research. Due to variety of organization in the sample chosen the major shortcoming of biasness in data collection has been alleviated to certain extent. Questions were framed using five points Likert scale based on various enablers of agility found through the literature survey. Respondent rated the various attribute of agility on five points Likert scale. Where 1 represent extremely important, 2 very important, 3 important, moderately important, and not important. Questionnaire were framed based on various agility enablers found through the literature survey, therefore it can be assumed that the survey administered questionnaire for the current research able to gather the reliable and valid information about the agility of Indian automotive industry. Additionally, the statistical validation was also done using Cronbach's alpha statistics and corrected item total correlation. Value of Cronbach's alpha was 0.778 and corrected item total correlation was excess of 0.38 for all the variables. This suggested high reliability, validity, and consistency in data collection.

Observations of various elements of agility extracted through literature survey suggested some correlation or interdependencies amongst these elements. The same was validated through statistical analysis, since the correlation matrix was not an identity matrix. In this situation the exploratory factor analysis was the obvious choice to reduce the data by putting highly correlated variable under one head known as factors. These factors were designated as agile capabilities and associated variable are agility enablers. Since the correlation between the various agile capabilities extracted were low, multiple regression analysis was performed to ascertain their relative importance in relation to sustainable strategic advantage. Model was validated at 5% level of significance.

The real world situation often involved subjectivity and vagueness hence become increasingly difficult to evaluate. Quantitative assessment of subjective matters always been a challenge for the researchers worldwide. Fuzzy logic provided comprehensive methodology for the assessment of real world objects. After surveying the various fuzzy based assessment methodology, it was decided to use fuzzy logic algorithm developed by Lin and associates. Fuzzy logic algorithm was chosen because of its ob-

vious advantages over others in assessing the agility along with the identification of various barriers to agility. Apart from this the methodology has been successfully applied in variety of industries including manufacturing & services. The methodology has been customized to ensure its relevancy for the current research.

Following were the steps of conducting fuzzy assessment.

1) Establish panel of experts to determine expected agility level and agility enablers to achieve it with the help of literature survey.

2) Collect information regarding the various enablers of agility through questionnaire administered survey.

3) Determine agile capabilities needed with the help of exploratory factor analysis. Ascertain the relative importance of various agile capabilities needed with the help of multiple regression analysis.

4) Rate and weight the various agility enables according to its significance in explaining the corresponding agile capability and with the help of expertise of the members of the panel in linguistic term. Because the extent of vagueness in agility the exact assessment is rather unrealistic. Evaluation is based on algorithm developed by Lin and associates [3].

    4.1 Approximate the linguistic assessment into fuzzy numbers.

    4.2 Compute FAI by aggregating the fuzzy weights & fuzzy ratings of the entire system.

    4.3 Convert FAI into corresponding linguistic term.

    4.4 Analyze the expected and existing level of agility. Identify potential barriers to agility using FPI.

Evaluation of FAI (Methodology 4.1)

The methodology has been customized to ensure its relevancy for the current research. Suppose there are m experts $\langle E_1, E_2 \cdots \cdots E_m \rangle$ in the panel to assess the n enablers of agility $\langle F_1, F_2 \cdots \cdots F_n \rangle$. $R_{jt} = (a_{jt}, b_{jt}, c_{jt})$ & $W_{jt} = (x_{jt}, y_{jt}, z_{jt})$ represent the fuzzy numbers for performance rating and weight mapped to corresponding linguistic term by the t-th evaluator to the j-th enabler of the agility. Then the aggregate performance rating and weight of m experts for the j-th agility enabler can be represented as follows (Methodology 4.1):

$$R_J = (a_j, b_j, c_j)$$
$$= (R_{j1} \oplus R_{j2} \oplus \cdots \cdots \oplus R_{jm}) \div m, \quad (1)$$

$$W_J = (x_j, y_j, z_j)$$
$$= (W_{j1} \oplus W_{j2} \oplus \cdots \cdots \oplus W_{jm}) \div m. \quad (2)$$

Evaluation of FAI of entire system (Methodology 4.2)

Fuzzy agility index (FAI) is basically the information consolidation of fuzzy ratings and weights of all the enablers of agility. FAI signifies the agility of the entire organization. FAI can be computed applying the following formula (Methodology 4.2).

$$\text{FAI} = \sum_{j=1}^{n}(W_J \otimes R_j) \Big/ \sum_{j=1}^{n} W_j. \quad (3)$$

Determination of agility level of an enterprise (Methodology 4.3)

Agility level of an enterprise is determined by matching the FAI with the corresponding linguistic level selected to represent the status of the enterprise agility. Several methodology have been suggested for the error free mapping. Euclidean distance methodology was suggested to measure closeness between the FAI and corresponding agility level. Suppose U_{ALi} and U_{FAI} represent the fuzzy membership functions of i-th level of agility and FAI respectively. Euclidean distance between U_{ALi} and U_{FAI} is computed applying the following formula

$$d(\text{FAI}, AL_i) = \left[\sum_{x \in p}(U_{FAI}(x) - U_{ALi}(x))^2\right]^{1/2}, \quad (4)$$

where

$$p = \{x_0, x_1, \cdots \cdots, x_m\} \subset [0, 1],$$
$$0 = x_0 < x_1 < \cdots < x_m = 1.$$
$$To \; simplify \; let \quad p = \quad \{0, 0.5, \cdots \cdots, 1\}$$

The smallest distance between U_{ALi} & U_{FAI} will identify the agility level of the enterprise and also helps in Identifying barriers to agility by ranking various agility enablers.

Evaluation of FPI (Methodology 4.4)

As described in the algorithm which, not only determine the present level of agility of an enterprise but also enable let managers identify key barriers to agility. This results in devising strategy to counter them and take suitable corrective measures. Another index FPII is defined known as fuzzy performance index to facilitate identification of barriers to agility. FPII identifies factors which impacts the level of agility and higher the FPII higher will the agility level or vice a versa. Since FPII takes into the effect

of performance rating & its corresponding weight into account, it becomes increasing difficult to assess the importance of agility barriers because low weight will nullify the high ratings or vice a versa. Therefore the following formula will be used to assess the contribution of ith enabler of the agility

$$\text{FPII}_i = R_i \ (\times) \ [(1,1,1) \ (-) \ W_i]. \quad (5)$$

For ranking of various agility barriers the left & right fuzzy ranking methodology is used because it preserves the ranking by taking into account the absolute location of the each of the fuzzy numbers.

Fuzzy max *imizing set is*

$$f_{\max} = \left[\begin{array}{ll} x, & 0 \le x \le 10 \\ 0, & \text{otherwise} \end{array} \right.$$

Fuzzy min *imizing set is*

$$f_{\min} = \left[\begin{array}{ll} 10 - x, & 0 \le x \le 10 \\ 0, & \text{otherwise} \end{array} \right.$$

The right score of FPII *is*
$$U_R(\text{FPII}) = \sup[f_{\text{FPII}}(x) \wedge f_{\max}(x)], \quad (6)$$

The left score of FPII *is*
$$U_L(\text{FPII}) = \sup[f_{\text{FPII}}(x) \wedge f_{\min}(x)]. \quad (7)$$

Finally the total score FPII is:

$$U_T(\text{FPII}) = [U_R(\text{FPII}) + 10 - U_L(\text{FPII})]/2. \quad (8)$$

Data analysis & interpretation

Data collected through the survey administered questionnaire was analyzed using SPSS 17. The statistical analysis suggested the value of Cronbach's alpha as 0.793. Value of Cronbach's alpha is excess of 0.5 indicates sufficient reliability, validity, and consistency of data measuring instrument pertaining to the research. Therefore it can be concluded that the various agility enablers extracted to measure the level of agility within SMEs automotive environment was reliable, valid, and consistent. The value of corrected item total correlation was more than 0.3 for all the enablers of agility. This suggested each of these variable made significant contribution in measuring agility, and hence none of the variables was deleted.

Bartlett's test of sphericity rejected the null hypothesis that correlation matrix was an identity matrix. Because the value of chi-square was very high & observed level of significance was less then 0.05. Furthermore the KMO statistics was 0.787. All these statistical values suggested the choice of conducting exploratory factory was appropriate for the current research.

Regarding the choice of number of stable extracted factor, it was decided to use Eigen value criterion along with total variance explained. Factors having Eigen values excess of one assumed to be stable and explain significant chunk of data. For the current research it was decided to extract four factors having the higher Eigen values and explained to gather more than 50% variation of data. Now total 27 variable explaining various enablers of agility have been reduced to just manageable four [2].

These extracted factors were agile capabilities of the Indian automotive SMEs, which explain the level of sustainable strategic advantage to Indian automotive SME.

Since the computed values of R-square and adjusted R-square are 0.652 and 0.646 respectively. Thus it can be safely assumed that there is no or minimum interaction amongst the extracted factors and they almost independently explain the sustainable strategic advantage. Hence we can proceed with the multiple regression analysis to ascertain individual contribution of these extracted factors. The value of F statistics and observe level of significance suggested highly significant regression model. Model explained 65.2% (R-square .652) of variation in sustainable strategic advantage. The proposed regression model can be framed with the help of the following equation.

$$SCA = 2.953 \oplus .864 FAC\_1 \oplus .230 FAC\_2$$
$$\oplus .097 FAC\_3 \oplus .214 FAC\_4, \quad (9)$$

where SCA-Sustainable strategic advantage, FAC_1 – Responsiveness, FAC_2 – Ability to reconfigure, FAC_3 – Competency, and FAC_4 – Ability to collaborate. It is quite evident from the model FAC_1 was the most important factor followed by FAC_2, FAC_4, and FAC_3 respectively.

With the help of exploratory factor analysis and multiple regression analysis the following conceptual model of the agility for India automotive industry can be framed (Table 1). Model serve as guide lines for evaluation of level of agility and identifying key barriers to agility (Methodology 2 & 3).

Panel comprises of front line managers of key auto parts manufacturer SMEs situated in Delhi NCR. Total 10 managers were selected to rate and weight the different attributes of manufacturing agility in relation to agile capability in linguistic terms. Assessor were also communicated regarding the outcome of the factors & regression analysis to facilitate the process of decision making. Thereafter aggregate rating and weight of each of the enablers was calculated using equation 1 &2 and assigned corresponding fuzzy number (Methodology 4).

Table 1
Conceptual model of agility.

Sustainable strategic advantage	Responsiveness (R)	Rapid prototyping (R1)
		Concurrent engineering (R2)
		Single minute exchange of die (R3)
		Integrated information system (R4)
		Short new product development time (R5)
		Short lead time of manufacturing (R6)
		Value engineering (R7)
		Total productive maintenance (R8)
		Business process integration (R9)
		Multi skilled people (R10)
		Cross functional team (R11)
	Ability to reconfigure (AR)	Adaptability of the organization (AR1)
		Proactive organization (AR2)
		Flexible layout (AR3)
		Flexible manufacturing system (AR4)
		Flexible people (AR5)
		Flexible organization (AR6)
		Risk identification & management system (AR7)
	Competency (C)	Cost leadership (C1)
		Customer driven quality (C2)
		Ability to identify & reduce waste in the system (C3)
	Ability to collaborate (AC)	Customer's participation in product design (AC1)
		Long term relationship with the suppliers (AC2)
		Supplier's managed inventory system (AC3)
		Supplier's participation in process & product design (AC4)

Using Eq. (3), the FAI of different agile capabilities were calculated and subsequently the FAI of the entire automotive SMEs was calculated.

FAI of entire automotive SMEs industry = (.31, .49, .67). Thereafter the computed value of FAI was matched with the linguistic assessment of level of agility, having membership function approximately same as the membership function of FAI obtained using (Table 2).

Apply equation 4 to calculate the Euclidean distance from FAI to each of fuzzy numbers mapped to different level of agility (Table 3).

According to the shortest Euclidean distance criterion, the current assessment of level of agility of Indian automotive industry was slightly agile. Next step was to perform gap analysis to find various barriers to agility and rank them, so that necessary

corrective actions can be taken accordingly. Apply Eqs (5), (6), and (7) to compute fuzzy performance index (FPII) of each of the enablers of agility and rank them (Table 4).

Table 2
Linguistic assessment of agility and its mapping to fuzzy numbers.

Symbol	Linguistic variables	Fuzzy numbers
EA	Extremely Agile	(.8, .9, 1)
VA	Very Agile	(.7, .8, .9)
A	Agile	(.6, .7, .8)
FA	Fairly Agile	(.5, .6, .7)
SA	Slightly Agile	(.4, .5, .6)
PA	Poorly Agile	(.3, .4, .5)
NA	Not Agile	(.2, .3, .4)
HNA	Highly Not Agile	(.1, .2, .3)
ENA	Extremely Not Agile	(0, .1, .2)

Table 3
Euclidean distance.

$$
\begin{bmatrix}
d & (\text{FAI, EA}) & = & .72, & d & (\text{FAI, VA}) & = & .55, & d & (\text{FAI, A}) & = & .38 \\
d & (\text{FAI, FA}) & = & .22, & d & (\text{FAI, SA}) & = & .11, & d & (\text{FAI, PA}) & = & .20 \\
d & (\text{FAI, NA}) & = & .21, & d & (\text{FAI, HNA}) & = & .52, & d & (\text{FAI, ENA}) & = & .68
\end{bmatrix}
$$

Table 4
FPII & Ranking of enablers of agility.

Agility Enabler	R_i			$(1,1,1) - W_i$			FPII			Ranking Score
R1	(.26,	.38,	.52)	(.02,	.10,	.20)	(.005,	.038,	.104)	.069
R2	(.30,	.49,	.67)	(.02,	.08,	.18)	(.006,	.040,	(.120)	.075
R3	(.30,	.49,	.67)	(.10,	.20,	.30)	(.030,	.098,	.201)	.135
R4	(.23,	.40,	.56)	(.10,	.20,	.30)	(.020,	.080,	.168)	.125
R5	(.31,	.53,	.75)	(.02,	.09,	.19)	(.006,	.101,	.142)	.113
R6	(.31,	.53,	.75)	(.02,	.08,	.18)	(.006,	.101,	.140)	.113
R7	(.21,	.37,	.53)	(.09,	.18,	.28)	(.019,	.067,	.150)	.099
R8	(.36,	.53,	.67)	(.04,	.11,	.21)	(.014,	.058,	.140)	.095
R9	(.21,	.37,	.53)	(.05,	.12,	.23)	(.010,	.045,	.122)	.076
R10	(.43,	.59,	.75)	(.05.	.12,	.23)	(.021,	.070,	.172)	.113
R11	(.30,	.50,	.70)	(.10,	.20,	.30)	(.030,	.100,	.21)	.140
AR1	(.31,	.50,	.69)	(.05,	.12,	.23)	(.015,	.060,	.160)	.102
AR2	(.29,	.47,	.65)	. (.10,	.20,	.30)	(.030,	.090,	.190)	.126
AR3	(.38,	.59,	.76)	(.13,	.24,	..36)	(.050,	.141,	.273)	.185
AR4	(.29,	.49,	.69)	(.02,	.08,	.18)	(.006,	.040,	.124)	.077
AR5	(.42,	.59,	.76)	(.08,	.17,	.27)	(.033,	.100,	.205)	.137
AR6	(.38,	.56,	.74)	(.09,	.18,	.28)	(.034,	.100,	.207)	.137
AR7	(.24,	.41,	.58)	(0.0,	.05,	.15)	(0.0,	.020,	.087)	.050
C1	(.34,	.53,	.72)	(.19,	.33,	.48)	(.064,	.175,	.345)	.226
C2	(.32,	.52,	.72)	(.05,	.12,	.22)	(.016,	.062,	.160)	.102
C3	(.36,	.55,	.73)	(.06,	.14,	.24)	(.021,	.077,	.175)	.105
AC1	(.25,	.43,	.60)	(.03,	.09,	.19)	(.007,	.038,	.114)	.125
AC2	(.40,	.58,	.75)	(.10,	.20,	.30)	(.04,	.116,	.225)	.156
AC3	(.20,	.35,	.50)	(.17,	.30,	.50)	(.034,	.105,	.25)	.159
AC4	(.27,	.46,	.64)	(.12,	.23,	.34)	(.032,	.105,	.217)	.147

With the help of Table 4, the various enablers of agility can be categorized into two cluster. Cluster one was labelled as extremely critical having the lowest ranking score. Cluster two was labelled as critical having the next lowest ranking score.

$$\text{Extremely Critical} =$$
$$\{AR7, \ R1, \ R2, \ AR4, \ R8, \ R7\},$$
$$\text{Critical} = \{AR1, \ C2, \ C3\}.$$

Discussion & Conclusion

Matching of FAI with the various agility level described using linguistic terms and corresponding fuzzy number by applying shortest Euclidean distance criterion suggested the current level of agility of Indian automotive industry as only slightly agile. Which was far-off from the targeted level of agility. Therefore it was necessary to find out the various critical barriers to agility. Fuzzy performance index (FPII) was computed for each of the enablers of agility. Thereafter score of each of the agility enablers was computed applying fuzzy left & right ranking methodology. Fuzzy left & right ranking methodol-

ogy suggested unbiased comprehensive platform to facilitate the ranking of various enablers of agility and subsequently helped in finding the critical barriers to agility. Key barriers to agility were classified into two categories namely, extremely critical & critical based on the ranking scores. Extremely critical barriers were risk identification & management system, rapid prototyping, concurrent engineering, flexible manufacturing system, total productive maintenance, and value engineering. The critical barriers were adaptability of the organization followed by customer driven quality, and ability to identify & reduce waste in the system. These key barriers to agility should be immediately taken care of starting from extremely critical to critical to have significant improvements in the agility of the Indian automotive SMEs.

Responsiveness was found as key factor to improve supply chain co-ordination within Indian SMEs environment applying interpretive structural modelling. Finding is in consensus with the present study [21].

Key barriers to agility were determined using fuzzy logic for the organizations. These key barriers are flexibility, speed of response, innovativeness,

and profitability. Some of them are in line with the present research [20].

Main obstacle in achieving manufacturing agility were cited as responsiveness, ability to customize, flexibility, and innovativeness. Many of these barriers to agility are in tune with the present study [22].

Organizational capabilities comprises of responsiveness & flexibility and organizational competence comprises of knowledge management were found as key barriers to agility in Iranian manufacturing industry. Which is by and large in line with the current research. The level of agility was divided into three categories namely pessimistic, optimistic, and mostly possible [24].

Fuzzy logic based quality functional deployment model was applied to find the key enablers of agility by evaluating their impact the organizational agility. Depending on the impact on organizational agility these key enablers of agility are, ability to customize, customer driven quality, cost optimization, and flexibility. Mostly in line with the present study [25].

Weakness of the study

Though fuzzy logic algorithm applied for the present research has found its applicability in variety of industries but there is lack literature available to compare with the findings of the current research in context of SMEs. This makes it difficult to validate the current research.

Direction for future research

There is a scope of improvement in fuzzy logic algorithm by taking other external factors into account. These comprises of customer or client interface and supplier interface.

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