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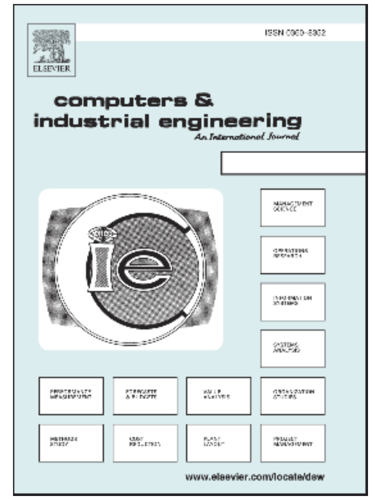

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A Fuzzy Sequential Model for Realization of Strategic Planning in Manufacturing Firms

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Abstract
Strategic planning is a vital management tool for projecting the long-range business goals and is not only for big businesses, but also applicable to small businesses in spite of their limited resources. To do this effectively, organizations should determine their strengths and weaknesses. Organizations have to produce appropriate action plans to overcome these weaknesses and it is very important to prioritize the action plans according to limited resources. In the current practice, a sequential model for overcoming this prioritization problem has not been studied in the related literature. Therefore we proposed a fuzzy sequential model (FSM) to help organizations in strategic planning process. This model includes four steps which are; determining open to improvement areas (OIAs), determining the root cause, developing action plans for each root cause and determining priority of OIAs hence action plans respectively. The proposed model was applied in a local manufacturing small medium enterprise (SME) as a real world case study. Results of the case study show that relatively more prioritized OIAs for the SME are, “mid-level managers take inadequate initiatives”, “failure to comply with the design calendar in Research & Development (R&D) and Product Development (P&D) processes”, “small lot sizes”, respectively.

Keywords: Strategic planning, multi criteria decision-making, SWOT analysis, Bolden’s taxonomy, fuzzy ANP, manufacturing SMEs

1. Introduction

Strategic planning is a management tool that enables employees to canalize the organization's targets. Strategic planning approach helps to identify long-term goals, current status and future plans of the organization via identifying root causes of problems in all levels of the entire organization. Organizations define visions after determining strategies and goals that help achieve objectives which are related to the vision with strategic planning. Also organizational performance are monitored with measurable criteria. The first step of strategic planning is the situation analysis. This analysis is aimed at identifying the current situation. Organizations can clearly see open to improvement areas (OIAs) by analyzing internal and external environment through SWOT (strengths, weaknesses, opportunities and threats) analysis.

Heuristic techniques are applied in strategic planning process in the related literature. Moynihan, Raj, Sterling, & Nichols (1995), described the design of a microcomputer-based decision support system that utilizes heuristic simulation techniques to planning at a strategic level. Also, Li, Ang, & Gay (1997), proposed a neural networks application, which consists of scenario generation for strategic business planning. There are studies of multi-criteria decision making (MCDM) methods with specific strategic decisions such as supplier evaluation and selection (Dulmin & Mininno, 2003; Chen, Lin, & Huang, 2006; Razmi, Rafiei, & Hashemi, 2009; Zeydan, Çolpan, & Çobanoğlu, 2011; Büyüközkan & Çifçi, 2012; Arabzad, Ghorbani, Razmi, & Shirouyehzad, 2015; Ayhan & Kılıç, 2015), however the number of studies on strategic planning are limited. Chiou, Tzeng, & Cheng (2005) proposed a fuzzy hierarchical analytic process to derive the weight of considered criteria and rank the importance of the criteria for sustainable development strategies. Dodangeh, Yusuff, & Jassbi (2010) proposed a model for selection and ranking of strategic plans in balanced scorecard using TOPSIS method and goal programming model. Perçin (2010) used ANP for selecting appropriate knowledge management strategies. Wu, Lin, & Lee (2010) proposed the marketing strategy decision making model by using ANP and TOPSIS method. Azimi, Yazdani-chamzini, Fooladgar, & Basiri (2011) proposed an integrated model for prioritizing the strategies of

Iranian mining sector. They applied ANP in order to obtain the weight of SWOT factors and ranked the strategies by using VIKOR technique. Zavadskas, Turskis, & Tamosaitiene (2011) developed a methodology for determining management strategies in construction enterprises management by applying SWOT and MCDM methods, analytic hierarchy process (AHP) and permutation. Baby (2013) proposed a model to optimize the strategies built by SWOT - QSPM (Quantitative Strategic Planning Matrix). The optimizing and rationalizing of the strategies were performed with the concept of AHP /ANP utilizing MCDM software. Ocampo, Clark, & Tanudtanud (2015) presented a decision framework that integration of manufacturing strategy by using probabilistic F-ANP method.

In this study we proposed a sequential model which consists of SWOT analysis, Root Cause Analysis (RCA), modified Bolden's taxonomy and fuzzy ANP methodologies. We used SWOT analysis to determine the strengths and weaknesses of the company. We used RCA to define main and sub-causes of the weaknesses. We improved Bolden's taxonomy by adding a new aspect (a fifth row) that helps to evaluate problems from social point of view. We used the modified Bolden's taxonomy to match OIAs, which was derived from the root causes of weakness, with probable action plans. Finally, we used fuzzy ANP to prioritize these action plans according to importance of OIAs. Fuzzy Sequential Model (FSM) helps in identifying which action plan will affect organization more. Thus FSM supports managers while making decisions on realization of strategic planning. Our contributions to the related literature are the development of a sequential model which enables effective usage of limited resources in strategic planning and extending Bolden's manufacturing taxonomy with the aspect of social impact.

2. Methodology

In this section we briefly described SWOT analysis, RCA, modified Bolden's taxonomy and F-ANP method that are used in the proposed model.

2.1. SWOT analysis

SWOT is an acronym for strengths, weaknesses, opportunities, and threats. SWOT analysis is a useful method for assessing organizations' internal factors (strengths and weaknesses) and external factors (opportunities and threats) in strategic planning process. The SWOT framework as a specific strategic tool was developed by Learned, Christensen, Andrews, & Guth (1965), from earlier efforts at the Harvard Business School to analyze case studies (Chermack & Kasshanna, 2007). The basic framework of SWOT analysis is shown in Table 1.

Table 1
The basic framework of SWOT (Chermack & Kasshanna, 2007)

	Strengths	**Weaknesses**
Opportunities	Achieve opportunities that greatly match the company's strengths	Overcome weaknesses to attain opportunities
Threats	Use strengths to reduce the company's vulnerability to threats	Prevent weaknesses to avoid making the company more susceptible to threats

2.2. Root cause analysis

Root causes are the real reason behind the problems. RCA is a process application that focuses on permanent solutions to the problems rather than smooth over the cracks. Root cause analysis techniques can be listed as; failure mode and effect analysis, Ishikawa diagram, change analysis, Pareto analysis and fault tree analysis. In this study, Ishikawa diagram is used in determining the root causes. The Ishikawa diagram which is also known as fishbone diagram, was proposed by Kaoru Ishikawa in the 1960s, who founded quality management processes in Kawasaki shipyards (Jayswal, Li, Anand, Loua, & Huang, 2011).

2.3. Modified Bolden's taxonomy

Bolden, Waterson, Warr, Clegg, & Wall (1997) proposed a taxonomy to provide a multi-disciplinary overview of the manufacturing fields. They contribute to the literature with an overall framework, summarizing and interrelating all the principal activities found within current manufacturing organizations as seen in Table 2.

Table 2
Modified Bolden's taxonomy

Primary Domain of App.	Business-focus			Organizational Focus	
	Improved quality (A)	**Reduced cost (B)**	**Responsiveness to customers (C)**	**Improved technology (D)**	**Employee development (E)**
Design and production (I)	1. Quality standards 2. Statistical process control 3. Total productive maintenance 4. Quality function deployment 5. Mistake proofing	1. Reduced work in progress 2. Just-in-time production 3. Process mapping 4. Smart design 5. Re-usability 6. Product rationalization	1. Rapid prototyping 2. Concurrent engineering 3. Customer involvement in design 4. Lead time reduction 5. Agile manufacture	1. Computer-aided process planning and control 2. Computer-integrated manufacturing systems 3. Automation 4. Computer-aided design and engineering	1. Job rotation 2. Multi-skilling 3. Psychometrics 4. Appraisal 5. Training and development 6. Suggestion schemes 7. Attitude surveys 8. Secondments 9. Safety management
Inventory and stock (II)	1. Supply chain partnering 2. Customer feedback 3. Conformance checks	1. Reduced inventory 2. Single sourcing 3. Just in time inventory control 4. Forecasting 5. Logistics management	1. Predicting customer requirements 2. Maintaining stock levels	1. Automated storage and retrieval systems 2. Electronic data interchange	1. Product team responsibility for purchasing and distribution
Work organization (III)	1. Quality improvement teams 2. Operator responsibility for quality 3. Quality feedback to operators 4. Quality training 5. Ergonomic design	1. Downsizing 2. Delayering 3. Outsourcing 4. Casual labor	1. Flexible work organization 2. After sales support 3. Cellular manufacture	1. Flexible manufacturing systems 2. Group technology 3. Computer supported management co-operative work 4. Manufacturing resource planning	1. Harmonization 2. Team-based work 3. Job enrichment 4. Boundary
Wider organization of manufacturing (IV)	1. Total quality management 2. Quality awards 3. Quality gurus 4. World class manufacturing 5. Benchmarking for quality	1. Lean production 2. Cost management 3. Financial performance measures 4. Time-based management 5. Benchmarking for costs	1. Priority given to customers 2. Market research 3. Customer surveys 4. Benchmarking for customer responsiveness 5. Business process re-engineering	1. Technology strategy for entire company 2. Computer-based management tools 3. Benchmarking for technology	1. Explicit company 2. HRM strategy 3. Employee empowerment 4. Performance-related pay 5. Culture change 6. Learning climate 7. Investors in people 8. Benchmarking for employee effectiveness
Social impact (V)	1. Paperless production 2. Recyclable package	1. Green supply chain management	1. New media 2. Branding and marketing	1. Renewable energy 2. HVAC Systems 3. Cogeneration Systems 4. Waste management 5. E-commerce	1. Training of employees' family 2. Family day

The benefits of a manufacturing practices taxonomy according to Bolden et al. include the following;

– Enables the identification of inter-relationships between practices in a clear manner.

- Assists in the identification of the differences and commonalities between practices.
- Enhances the identification of practices for researchers and practitioners from a variety of backgrounds.
- Promotes the identification of gaps between theory and practice (Walden, 2007).

Bolden's taxonomy helps to find out which areas to focus on, for related problems of the company. Bolden's classification scheme for development of their taxonomy is shown in Table 2. For instance, if a company is dealing with inventory and stock problems, and wants to reduce costs they should seek solution in those 5 practices (IIB1-Reduced inventory, IIB2-Single sourcing, IIB3-Just in time inventory control, IIB4-Forecasting, IIB5-Logistics management) listed in second row (row II), second column (column B).

Bolden et al. proposed this taxonomy in 1997. However, with the help of rapidly developing internet and communication technologies (ICT), social aspect is crucial for the companies in today's competitive world. Both internal and external stakeholders of the company have arising awareness to their new responsibilities to each other and to the environment. Organization for Economic Co-operation and Development (OECD) reports indicate that ICT, green growth and social impact are prioritized areas (*OECD Innovation strategy 2015 An agenda for policy action*, 2015). For these reasons, our contribution to this taxonomy with the aspect of social impact can be seen in the fifth row.

2.4. Fuzzy analytic network process (F-ANP)

MCDM is a sub-discipline of operations research that explicitly considers multiple criteria in decision making environments (Achillas, Moussiopoulos, Karagiannidis, Banias, & Perkoulidis, 2013). These methods deal with decision making processes and are appropriate research methods that can be used in selecting and sorting out alternatives. In the decision process, objectives, quantitative or qualitative criteria are assessed for each alternative at the same time. AHP is one of the popular MCDM methods which works on priority theory and was developed by Saaty (1980). ANP is the general form of AHP (Saaty, 1996).

The first phase of ANP compares the measuring criteria in the overall system to form a super-matrix. This can be accomplished using pair-wise comparisons (Liou, Tzeng, & Chang, 2007). Triangular fuzzy numbers and fuzzy linguistic terms for using pairwise comparisons are given in Table 3. Experts use linguistic expressions while evaluating criteria. For this reason, the fuzzy linguistic scale shown in Table 3 is used in the experts' opinions.

Table 3
The triangular fuzzy numbers and linguistic variables

Linguistic variables	Fuzzy number	Triangular fuzzy numbers	Triangular fuzzy reciprocal numbers
Equally Important (EI)	$\tilde{1}$	(1; 1; 1)	(1; 1; 1)
Weekly Important (WI)	$\tilde{3}$	(1; 3; 5)	(1/5; 1/3; 1)
Strongly Important (SI)	$\tilde{5}$	(3; 5; 7)	(1/7; 1/5; 1/3)
Very Important (VI)	$\tilde{7}$	(5; 7; 9)	(1/9; 1/7; 1/5)
Absolutely Important (AI)	$\tilde{9}$	(7; 9; 9)	(1/9; 1/9; 1/7)

We used a simple extent analysis method proposed by Chang, (1996) for F-ANP weight derivation. Extent analysis method is selected in this study because of a broader use in related literature and also it has less computational complexity by using triangular fuzzy numbers. We described extent analysis method below.

Let $X = \{x_1, x_2, \dots, x_n\}$ be an object set, and $G = \{g_1, g_2, \dots, g_m\}$ be a goal set.

$M_{g_i}^1, M_{g_i}^2, \dots, M_{g_i}^m, \quad i = 1, 2, \dots, n$ where all the $M_{g_i}^j (j = 1, 2, \dots, m)$ are triangular fuzzy numbers.

Step 1: The value of fuzzy synthetic extent with respect to the i^{th} object is defined as

$$S_i = \sum_j^m M_{g_i}^j \otimes \left[\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j\right]^{-1} \tag{1}$$

To obtain $\sum_j^m M_{g_i}^j$, perform the fuzzy addition operation of *m* extent analysis values for a particular matrix such that

$$\sum_j^m M_{g_i}^j = \left(\sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j\right), \tag{2}$$

and to obtain $\left[\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j\right]^{-1}$, perform the fuzzy addition operation of $M_{g_i}^j (j = 1, 2, \dots, m)$ values such that

$$\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j = \left(\sum_{i=1}^n l_i, \sum_{i=1}^n m_i, \sum_{i=1}^n u_i\right) \tag{3}$$

$$\left[\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^n l_i}, \frac{1}{\sum_{i=1}^n m_i}, \frac{1}{\sum_{i=1}^n u_i}\right) \tag{4}$$

Step 2: The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as

$$V(M_2 \geq M_1) = sup\left[min\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)\right]$$

and can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1, & \text{if } m_2 \geq m_1, \\ 0, & \text{if } l_1 \geq u_2, \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{otherwise,} \end{cases} \tag{5}$$

where *d* is the ordinate of the highest intersection point *d* between μ_{M_1} and μ_{M_2}. Both values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$ are required in order to compare M_1 and M_2.

Step 3: The degree possibility for a convex fuzzy number to be greater than *k* convex fuzzy numbers $M_i (i = 1, 2, \dots, k)$ can be defined by

$$V(M \geq M_1, M_2, \dots, M_k) = V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and} \dots \text{and } (M \geq M_k)]$$
$$= \min V(M \geq M_i), \quad i = 1, 2, \dots, k. \tag{6}$$

Assume that

$$d'(A_i) = \min V(S_i \geq S_k) \quad \text{for } k = 1, 2, \dots, n; k \neq i. \tag{7}$$

Then the weight vector is given by

$$W' = \left(d'(A_1), d'(A_2), \dots, d'(A_n)\right)^T, \tag{8}$$

where $A_i (i = 1, 2, \dots, n)$ are *n* elements.

Step 4: Via the normalization, the normalized weight vectors are

$$W = \left(d(A_1), d(A_2), \dots, d(A_n)\right)^T, \text{where } W \text{ is a non-fuzzy number.} \tag{9}$$

3. Proposed model and application

In this section we described proposed model and the application of the model in a manufacturing small medium enterprise (SME).

3.1. Fuzzy sequential model

FSM consists of four consecutive methodologies. As shown in Figure 1, first step is identifying OIAs through SWOT analysis. The second step is identifying the root cause of problems in OIAs by RCA. The subsequent step is developing action plans for each root cause through Bolden's taxonomy of modern manufacturing practices. We enhanced Bolden’s best practice taxonomy by a modest modification of adding social impact aspect. All action plans are recommended with respect to the limited resources such as time, cost and workforce. We believe action plans should be prioritized and applied in a particular order because most of the SMEs have major problems with limited resources. At this point problem priorities were determined by using fuzzy analytic network process (F-ANP) method. Furthermore, we applied this fuzzy approach to continuous improvement model, in a manufacturing SME as a real world case study.

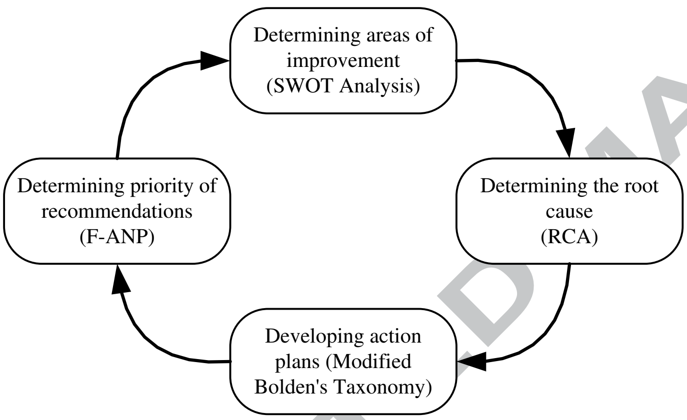

Fig. 1. Steps of proposed fuzzy sequential model

3.2. Application of FSM in a manufacturing firm

Proposed model was applied in a manufacturing SME. In order to preserve confidentiality, this company is referred to as ABC company. ABC is an SME that produces manual, semi-automatic and automatic band saw machines since 1994. The company employs around 75 people. The major activities in the company include engineering (Research & Development, Product Development), manufacturing, purchasing, export and import. We examined the ABC company on the basis of departments. In total, eight departments were evaluated. These departments are production planning, product development, manufacturing, quality assurance, purchasing-procurement, management and organization, accounting and finance, human resources and sales and marketing.

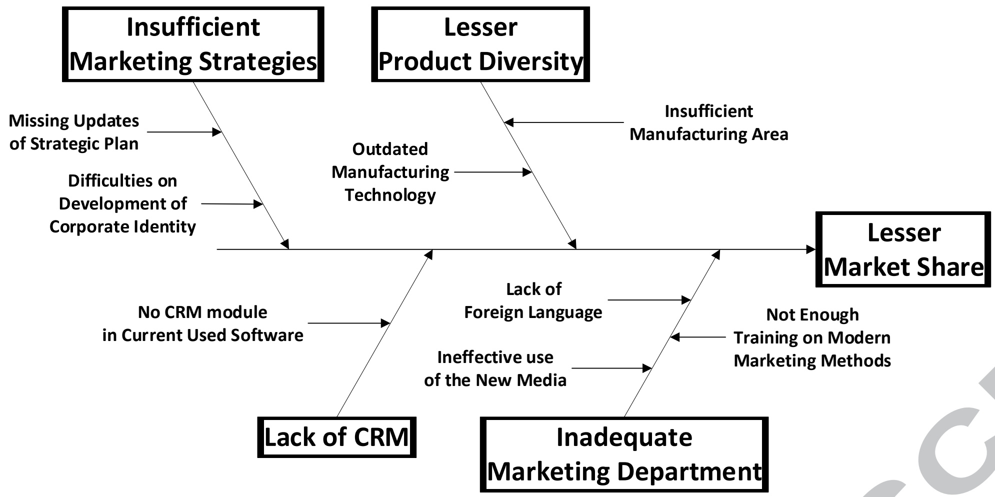

Fig. 2. Root cause analysis of OIA 1.5 Lesser market share

We organized meetings with attendees of relevant department managers, for determining strengths and OIAs of departments. We identified root causes with a core team consisting of senior manager, unit supervisor and blue-collar workers. Ishikawa diagram as shown in Figure 2 is used for determining the root cause of each area with the core team. "Lesser market share" problem (OIA 1.5) has been selected and shown in Figure 2 as an illustrative example for RCA. Four major causes were determined by the ABC company professionals. These are "insufficient marketing strategies", "lesser product diversity", "lack of customer relationship management (CRM)" and "inadequate marketing department". Inadequate marketing department was evaluated as the most important cause of lesser market share for the ABC company. Root cause of inadequate market department was determined as ineffective use of the new media. As a result of the meetings 12 OIAs were determined and were matched with root causes. 18 different action plans for ABC company are shown in Table 4. Open to improvement areas are determined in three levels which are strategic, tactical and operational in the Table 4. For instance, OIA 1.5 was evaluated in strategic level. "Ineffective use of new media" was determined as a root cause of OIA 1.5. As a result of the discussions in ABC company, VC1 (New media) and VC2 (Branding and marketing) were selected in modified Bolden's taxonomy as shown in Table 2 for action plans of OIA 1.5.

Table 4
Open to improvement areas in ABC company

Level	No	Open to improvement areas	Root cause	Action plans
S1. Strategic	OIA 1.1	Inconsistency of the annual budget plan	Ineffective cost management	IVB2
	OIA 1.2	Lack of CRM	Lack of workforce and software	IVC1-IVC3
	OIA 1.3	Lack of E-commerce	Lack of technological infrastructure	VD5
	OIA 1.4	The inability to forecast demand	Inadequate market information	IVC2-IIB4
	OIA 1.5	Lesser market share	Ineffective use of new media	VC1-VC2
S2. Tactical	OIA 2.1	Failure to comply with the design calendar in Research & Development (R&D) and Product Development (P&D) processes	Market profile	IIC1
	OIA 2.2	Late arriving purchase parts	Ineffective purchasing management	IIE1-IID2
	OIA 2.3	Mid-level managers take inadequate initiatives	Lack of organizational culture	IVE5-IIIE3
S3. Operational	OIA 3.1	Lack of standard operating times	Lack of necessary labor	IVE3-IVE4
	OIA 3.2	Small lot sizes	High diversity of parts	IB4-IIID2
	OIA 3.3	Unknown location of materials in storage yard	Disorder of storage yard	IID1
	OIA 3.4	Inadequate assembly yard	Ineffective layout	IIID2

4. Results

We aimed at better usage of resources for realization of strategic planning. Therefore we prioritized the OIAs by using F-ANP method. According to F-ANP method first we gathered expert opinions. Determining prioritization of OIAs provides prioritization of action plans based on OIAs. In our study we have gathered 5 experts' opinion. The impact relation map for the levels according to company managers is shown in Figure 3.

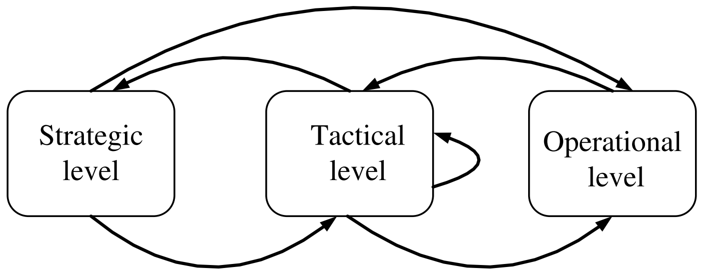

Fig. 3. Impact relation map

Pairwise comparisons were carried out to determining impact relation map. First expert's opinions are given in Table 5. According to the expert opinions, the weights of the sub-criteria are calculated. For example, since S1 (strategic level) affects S2 (tactical level) as shown in Figure 3, the fuzzy evaluation of importance of sub-criteria of S2 (OIA 2.1, OIA 2.2 and OIA 2.3) in terms of OIA 1.1, OIA 1.2, OIA 1.3, OIA 1.4 and OIA 1.5 are given in Table 5.

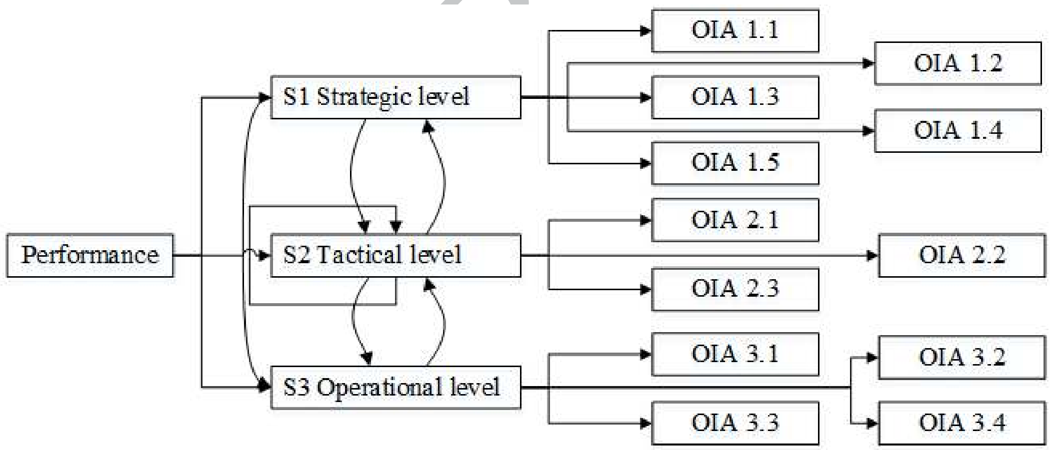

Fig. 4. Network structure of FSM in ABC company

As seen in Figure 4 and Figure 3 there are 6 relationships between the levels. Strategic level effects both tactical level and operational level. Operational level effects tactical level. Tactical level effects strategic level, operational level and also effects itself. Strategic, tactical and operational levels include; 5 OIAs, 3 OIAs and 4 OIAs, respectively.

Table 5
Pairwise comparison matrix of first expert terms of OIA 1.1, OIA 1.2, OIA 1.3, OIA 1.4 and OIA 1.5

		Linguistic variables			Fuzzy numbers		
		OIA 2.1	OIA 2.2	OIA 2.3	OIA 2.1	OIA 2.2	OIA 2.3
OIA 1.1	OIA 2.1	1	7	3	(1;1;1)	(5;7;9)	(1;3;5)
	OIA 2.2	1/7	1	1/5	(1/9;1/7;1/5)	(1;1;1)	(1/7;1/5;1/3)
	OIA 2.3	1/3	5	1	(1/5;1/3;1)	(3;5;7)	(1;1;1)
OIA 1.2	OIA 2.1	1	3	1/5	(1;1;1)	(1;3;5)	(1/7;1/5;1/3)
	OIA 2.2	1/3	1	1/3	(1/5;1/3;1)	(1;1;1)	(1/5;1/3;1)
	OIA 2.3	5	3	1	(3;5;7)	(1;3;5)	(1;1;1)
OIA 1.3	OIA 2.1	1	1/7	1/3	(1;1;1)	(1/9;1/7;1/5)	(1/5;1/3;1)
	OIA 2.2	7	1	1/3	(5;7;9)	(1;1;1)	(1/5;1/3;1)
	OIA 2.3	3	3	1	(1;3;5)	(1;3;5)	(1;1;1)
OIA 1.4	OIA 2.1	1	3	5	(1;1;1)	(1;3;5)	(3;5;7)
	OIA 2.2	1/3	1	1/3	(1/5;1/3;1)	(1;1;1)	(1/5;1/3;1)
	OIA 2.3	1/5	3	1	(1/7;1/5;1/3)	(1;3;5)	(1;1;1)
OIA 1.5	OIA 2.1	1	5	3	(1;1;1)	(3;5;7)	(1;3;5)
	OIA 2.2	1/5	1	1/3	(1/7;1/5;1/3)	(1;1;1)	(1/5;1/3;1)
	OIA 2.3	1/3	3	1	(1/5;1/3;1)	(1;3;5)	(1;1;1)

Priorities are calculated using the formula [1-9]. Priorities of OIAs are given in Figures 5-7, separately according to levels

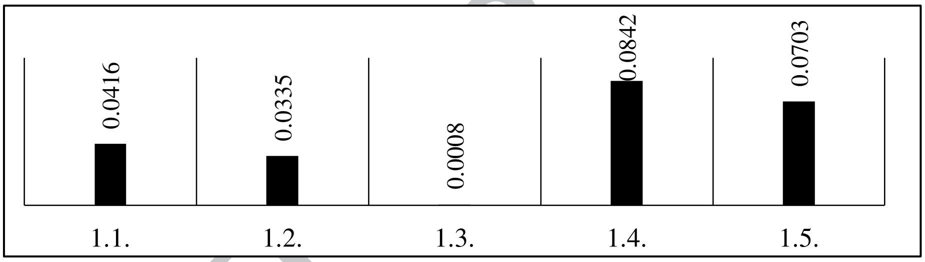

Fig. 5. Strategic level criteria weights

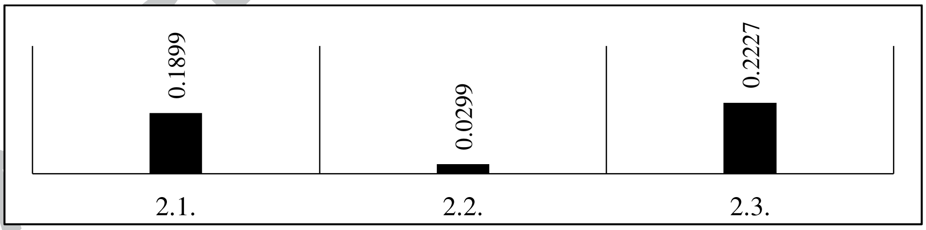

Fig. 6. Tactical level criteria weights

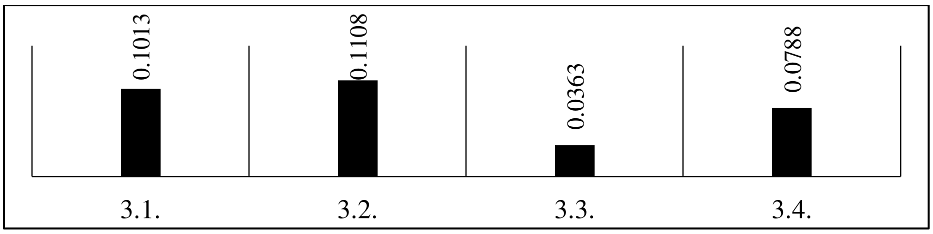

Fig. 7. Operational level criteria weights

Total distribution of OIAs are respectively; 33% of operational level OIAs, 44% of tactical level OIAs and 23% of strategic level OIAs. 12 OIAs are ranked from most important to least important in Table 6.

Table 6
List of Prioritized OIAs

Open to improvement areas		Percentage	Rank
OIA 2.3	Mid-level managers take inadequate initiatives	22.27%	1
OIA 2.1	Failure to comply with the design calendar in R&D and P&D processes	18.99%	2
OIA 3.2	Small lot sizes	11.08%	3
OIA 3.1	Lack of standard operating times	10.13%	4
OIA 1.4	The inability to forecast demand	8.42%	5
OIA 3.4	Inadequate assembly yard	7.88%	6
OIA 1.5	Lesser market share	7.03%	7
OIA 1.1	Inconsistency of the annual budget plan	4.16%	8
OIA 3.3	Unknown location of materials in storage yard	3.63%	9
OIA 1.2	Lack of CRM	3.35%	10
OIA 2.2	Late arriving purchase parts	2.99%	11
OIA 1.3	Lack of E-commerce	0.08%	12

As it is clearly seen from Table 6, first three OIAs have major importance with a percentage of OIA 2.3 with 22.27%, OIA 2.1 with 18.99% and OIA 3.2 with 11.08% respectively. These three major OIAs are of critical importance to ABC company.

Table 7
Action plans for major OIAs

OIAs	Action Code	Action Description
OIA 2.3.	IVE5 IIIE3	Culture change Job enrichment
OIA 2.1.	IIC1	Predicting customer requirements
OIA 3.2.	IB4 IIID2	Smart design Group technology

Action plans coded with "IVE5-IIIE3", "IIC1" and "IB4-IIID2" from Table 4 are the selected most important action plans which are related to OIA 2.3, OIA 2.1 and OIA 3.2 respectively. For instance "IVE5" can be found from modified Bolden's taxonomy in Table 2 as "4th row, column E, bullet 5: Culture change". After this matching, relevant action plans for major three OIAs are listed in Table 7.

5. Conclusions

In today's competitive world, many SMEs are facing lack of resources such as time, money and workforce. While it has already been a crucial problem for SMEs to make long term goals and make strategic decisions, they suffer more when it comes to allocating necessary resources for the realization of strategic plans. In this study we built a sequential model consisting of different methodologies to relax this problem. This sequential model includes four steps which are; determining OIAs, determining the root cause, developing action plans for each root cause and determining priorities of OIAs.

The proposed model had been applied in a local manufacturing SME. First we made a SWOT analysis to determine OIAs. Starting from this point of view, we tried to find out what the root causes of the OIAs are with RCA. Subsequently we matched each root cause to an action plan according to modified Bolden's taxonomy. We believe social impact is an unignorable aspect that is why we added fifth row to the Bolden's taxonomy. As a result of this step we determined 12 OIAs matched with root causes and 18 different action plans for ABC company. Afterwards we used F-ANP to prioritize OIAs with pairwise comparisons.

Eventually we managed to prioritize possible action plans to those OIAs. Therefore this model gives rankings and insights about which problem/OIA has more important role for the SME according to strategic planning. We believe this study has two distinguished contributions to the related literature. The first one is the development of a sequential model which enables effective usage of limited resources in strategic planning. The second one is enhancing Bolden's manufacturing taxonomy with the aspect of social impact. This study can be used by both researchers and industrial practitioners in the field of strategic planning and decision making. For the future studies, action plan prioritizing method used in the FSM can be compared and improved with other MCDM methods.

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Table 1
The basic framework of SWOT (Chermack & Kasshanna, 2007)

	Strengths	**Weaknesses**
Opportunities	Achieve opportunities that greatly match the company's strengths	Overcome weaknesses to attain opportunities
Threats	Use strengths to reduce the company's vulnerability to threats	Prevent weaknesses to avoid making the company more susceptible to threats

Table 2
Modified Bolden's taxonomy

Primary Domain of App.	**Business-focus**			**Organizational Focus**	
	Improved quality (A)	**Reduced cost (B)**	**Responsiveness to customers (C)**	**Improved technology (D)**	**Employee development (E)**
Design and production (I)	1. Quality standards 2. Statistical process control 3. Total productive maintenance 4. Quality function deployment 5. Mistake proofing	1. Reduced work in progress 2. Just-in-time production 3. Process mapping 4. Smart design 5. Re-usability 6. Product rationalization	1. Rapid prototyping 2. Concurrent engineering 3. Customer involvement in design 4. Lead time reduction 5. Agile manufacture	1. Computer-aided process planning and control 2. Computer-integrated manufacturing systems 3. Automation 4. Computer-aided design and engineering	1. Job rotation 2. Multi-skilling 3. Psychometrics 4. Appraisal 5. Training and development 6. Suggestion schemes 7. Attitude surveys 8. Secondments 9. Safety management
Inventory and stock (II)	1. Supply chain partnering 2. Customer feedback 3. Conformance checks	1. Reduced inventory 2. Single sourcing 3. Just in time inventory control 4. Forecasting 5. Logistics management	1. Predicting customer requirements 2. Maintaining stock levels	1. Automated storage and retrieval systems 2. Electronic data interchange	1. Product team responsibility for purchasing and distribution
Work organization (III)	1. Quality improvement teams 2. Operator responsibility for quality 3. Quality feedback to operators 4. Quality training 5. Ergonomic design	1. Downsizing 2. Delayering 3. Outsourcing 4. Casual labor	1. Flexible work organization 2. After sales support 3. Cellular manufacture	1. Flexible manufacturing systems 2. Group technology 3. Computer supported management co-operative work 4. Manufacturing resource planning	1. Harmonization 2. Team-based work 3. Job enrichment 4. Boundary
Wider organization of manufacturing (IV)	1. Total quality management 2. Quality awards 3. Quality gurus 4. World class manufacturing 5. Benchmarking for quality	1. Lean production 2. Cost management 3. Financial performance measures 4. Time-based management 5. Benchmarking for costs	1. Priority given to customers 2. Market research 3. Customer surveys 4. Benchmarking for customer responsiveness 5. Business process re-engineering	1. Technology strategy for entire company 2. Computer-based management tools 3. Benchmarking for technology	1. Explicit company 2. HRM strategy 3. Employee empowerment 4. Performance-related pay 5. Culture change 6. Learning climate 7. Investors in people 8. Benchmarking for employee effectiveness
Social impact (V)	1. Paperless production 2. Recyclable package	1. Green supply chain management	1. New media 2. Branding and marketing	1. Renewable energy 2. HVAC Systems 3. Cogeneration Systems 4. Waste management 5. E-commerce	1. Training of employees' family 2. Family day

Table 3
The triangular fuzzy numbers and linguistic variables

Linguistic variables	Fuzzy number	Triangular fuzzy numbers	Triangular fuzzy reciprocal numbers
Equally Important (EI)	$\tilde{1}$	(1, 1, 1)	(1, 1, 1)
Weekly Important (WI)	$\tilde{3}$	(1, 3, 5)	(1/5, 1/3, 1)
Strongly Important (SI)	$\tilde{5}$	(3, 5, 7)	(1/7, 1/5, 1/3)
Very Important (VI)	$\tilde{7}$	(5, 7, 9)	(1/9, 1/7, 1/5)
Absolutely Important (AI)	$\tilde{9}$	(7, 9, 9)	(1/9, 1/9, 1/7)

Table 4
Open to improvement areas in ABC company

Level	No	Open to improvement areas	Root cause	Action plans
S1. Strategic	OIA 1.1	Inconsistency of the annual budget plan	Ineffective cost management	IVB2
	OIA 1.2	Lack of CRM	Lack of workforce and software	IVC1-IVC3
	OIA 1.3	Lack of E-commerce	Lack of technological infrastructure	VD5
	OIA 1.4	The inability to forecast demand	Inadequate market information	IVC2-IIB4
	OIA 1.5	Lesser market share	Ineffective use of new media	VC1-VC2
S2. Tactical	OIA 2.1	Failure to comply with the design calendar in Research & Development (R&D) and Product Development (P&D) processes	Market profile	IIC1
	OIA 2.2	Late arriving purchase parts	Ineffective purchasing management	IIE1-IID2
	OIA 2.3	Mid-level managers take inadequate initiatives	Lack of organizational culture	IVE5-IIIE3
S3. Operational	OIA 3.1	Lack of standard operating times	Lack of necessary labor	IVE3-IVE4
	OIA 3.2	Small lot sizes	High diversity of parts	IB4-IIID2
	OIA 3.3	Unknown location of materials in storage yard	Disorder of storage yard	IID1
	OIA 3.4	Inadequate assembly yard	Ineffective layout	IIID2

Table 5
Pairwise comparison matrix of first expert terms of OIA 1.1, OIA 1.2, OIA 1.3, OIA 1.4 and OIA 1.5

		Linguistic variables			Fuzzy numbers		
		OIA 2.1	OIA 2.2	OIA 2.3	OIA 2.1	OIA 2.2	OIA 2.3
OIA 1.1	OIA 2.1	1	7	3	(1;1;1)	(5;7;9)	(1;3;5)
	OIA 2.2	1/7	1	1/5	(1/9;1/7;1/5)	(1;1;1)	(1/7;1/5;1/3)
	OIA 2.3	1/3	5	1	(1/5;1/3;1)	(3;5;7)	(1;1;1)
OIA 1.2	OIA 2.1	1	3	1/5	(1;1;1)	(1;3;5)	(1/7;1/5;1/3)
	OIA 2.2	1/3	1	1/3	(1/5;1/3;1)	(1;1;1)	(1/5;1/3;1)
	OIA 2.3	5	3	1	(3;5;7)	(1;3;5)	(1;1;1)
OIA 1.3	OIA 2.1	1	1/7	1/3	(1;1;1)	(1/9;1/7;1/5)	(1/5;1/3;1)
	OIA 2.2	7	1	1/3	(5;7;9)	(1;1;1)	(1/5;1/3;1)
	OIA 2.3	3	3	1	(1;3;5)	(1;3;5)	(1;1;1)
OIA 1.4	OIA 2.1	1	3	5	(1;1;1)	(1;3;5)	(3;5;7)
	OIA 2.2	1/3	1	1/3	(1/5;1/3;1)	(1;1;1)	(1/5;1/3;1)
	OIA 2.3	1/5	3	1	(1/7;1/5;1/3)	(1;3;5)	(1;1;1)
OIA 1.5	OIA 2.1	1	5	3	(1;1;1)	(3;5;7)	(1;3;5)
	OIA 2.2	1/5	1	1/3	(1/7;1/5;1/3)	(1;1;1)	(1/5;1/3;1)
	OIA 2.3	1/3	3	1	(1/5;1/3;1)	(1;3;5)	(1;1;1)

Table 6
List of Prioritized OIAs

Open to improvement areas		Percentage	Rank
OIA 2.3	Mid-level managers take inadequate initiatives	22.27%	1
OIA 2.1	Failure to comply with the design calendar in R&D and P&D processes	18.99%	2
OIA 3.2	Small lot sizes	11.08%	3
OIA 3.1	Lack of standard operating times	10.13%	4
OIA 1.4	The inability to forecast demand	8.42%	5
OIA 3.4	Inadequate assembly yard	7.88%	6
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Table 7
Action plans for major OIAs

OIAs	Action Code	Action Description
OIA 2.3.	IVE5	Culture change
	IIIE3	Job enrichment
OIA 2.1.	IIC1	Predicting customer requirements
OIA 3.2.	IB4	Smart design
	IIID2	Group technology

Highlights

- A sequential model for effective resource usage realization of strategic planning.
- Consists of four different techniques; SWOT, RCA, Bolden's taxonomy and Fuzzy ANP.
- Applied in a local manufacturing SME.
- Action plans are ranked due to their importance levels.
- Suitable model for both researches and industrial practitioners.

Graphical abstract