

Applying Fuzzy Logic in Assessing the Readiness of the Company for Implementing ERP

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Abstract: ERP (Enterprise Resource Planning) plays an important role to integrate organization's information and functions in all areas and finally results in successful operation in global markets. In underdeveloped countries, most companies have been forced to join global markets. But ERP implementation is costly and time consuming project and unreadiness of the company for this implementation can lead to loss of many valuable resources of the company. Therefore, assessing the readiness of the company for implementing ERP before its implementation is essential. Many factors are essential in determining a company's readiness for ERP implementation. Since most of these factors are qualitative and relations between them are very complicated, determining their exact quantitative values is quiet difficult. Using fuzzy logic can be helpful to simplify the calculations and finally leads to a more precise result to determine qualitative problems like readiness of a company for ERP implementation. In this study, we intended to gather critical success factors for ERP implementation and design a Fuzzy System to assess the readiness of a company for ERP. This research is done in a famous auto company in Iran. According to this study the readiness for ERP implementation of this company was low.

Key words: Enterprise Resource Planning • Assessing readiness • Critical Success Factors • Fuzzy System

INTRODUCTION

Enterprise Resource Planning (ERP) is a software system to manage business which supports all of operational areas such as planning, production, selling, marketing, distribution, accounting and financial, human resource, inventory management, maintenance, transportation and e-business. The most important feature of ERP is its ability to integrate and automate the process of businesses, share information in the whole company and provide and access to well –timed information [1].

As in underdeveloped countries most companies have been forced to join global markets. In such situation, ERP as a significant tool of information and communication that technologies plays an important role to integrate organization's information and functions in all areas. Finally, its result in successful operation of a company in global market can be guaranteed. Although companies spend a great amount of money on ERP packages and the implementation process, there is extensive evidence that they experience considerable problems, particularly during the actual implementation project. ERP implementation is costly and time consuming and unreadiness of a company for this implementation can lead to waste of many valuable resources of the company.

Therefore, assessing the readiness of the company for implementing ERP before its implementation is essential and can protect companies from failures resulting from its unreadiness in implementing.

Great deals of vital factors are involved in determining a company's readiness for ERP implementation. Since most of these factors are qualitative and relations between them are very complicated, determining their values by exact quantity is quiet difficult. Therefore, using fuzzy logic can be helpful to simplify the calculations and finally leads to a more precise result to determine qualitative problems like readiness of a company for ERP implementation. So, this research seeks to develop a Fuzzy system by using Critical Success Factors CSFs to assess the readiness of a company for ERP implementation.

There has been a developing body of academic literature which addresses the difficulties of ERP implementation by proposing (CSFs) and process models of the implementation. Both are aimed at better planning and hence more successful ERP implementation

Parr and Shanks (1999) suggested some critical factors for ERP implementation success in their research including commitment and support of management, use of full time team for implementation, project scheduling,

change management, coordinated team, definition of goals and needs, empowered project team [2]. Holland *et al.* (1999) divided CSFs in to 2 categories: strategic and tactical. The strategic factors including legacy systems, business vision, top management support, project schedule/plans and the tactical factors including client consultation, personnel, business process change and client acceptance [3]. Parr *et al.* (1999) divided CSFs into groups related with management, personnel, software and project [4]. Esteves and Pastor (2000) suggested that the factors should be categorized into strategic and tactical factors from organizational and technological perspectives [4]. Marsh (2000) suggested that key success factors for ERP implementation include organizational experience of similar scale IT or organizational change projects [5]. Al-Mudimigh *et al.* (2001) categorized CSFs according to strategic, tactical and operational categories [6]. Nah *et al.* (2001), based on a study of earlier papers identified 11 factors that were critical to ERP implementation success. Those factors were ERP teamwork and composition, change management program and culture, top management support, business plan and vision, business process reengineering, effective communication, project management and appropriate business and information technology legacy systems [1]. Somers and Nelson (2001) asked US executive to rank the ERP CSFs and producing the following "top 10" in terms of the mean score: Top management support, Project team competence, Interdepartmental cooperation, Clear goals and objectives, Project champion, Vender support, careful package selection [7]. Zhe Zhang *et al.* (2004) organized CSFs into 4 environments including organizational environment (top management support, business process reengineering, effective project management, organizational culture), user environment (education and training, user involvement, user characteristics), system environment (information quality, system quality), ERP vendor environment (ERP vendor quality) [8]. David Olson (2004) identified ten critical success factors for ERP implementation that includes clear understanding of strategic goals, top management support, project management, implementation team, organizational commitment to change, extensive education and training, data accuracy [9]. Finney and Corbett (2007), based on a review of earlier papers, group the factors into strategic and tactical categorizes. Strategic factors including top management commitment and support, visioning and planning, implementation strategy and time frame, project

management, change management and tactical factors including balanced team, project team: the best and brightest, communication plan, empowered decision makers, team morale and motivation, project cost planning and management, BPR and software configuration, legacy system consieration, IT infrastructure, client consultation, selection of ERP, consultant selection and relationship, training and job redesign, data conversion and integrity [6]. Ngai *et al.* (2008) identified eighteen CSFs for the successful ERP implementation including appropriate business and IT legacy systems, business process engineering, change management, communication, ERP team work and composition, project management, top management support, organizational characteristics [10].

Each study addresses the difficulties of ERP implementation by proposing critical success factors in the next section. we are gathering these factors as our research framework.

Research Framework: Reviewing earlier researches on critical success factors for ERP implementation, 42 factors were recognized to be essential for a successful implementation of ERP. Some factors such as Vendor support, minimum customization or ERP package selection concerning ERP software and buying the ERP package were set aside and the other factors considered in Al-Mudimigh *et al.*'s model (2001) which were classified in three categories of strategic, tactical and operational, then they were confirmed with ERP experts.

Strategic Factors: Strategic factors are those that show a whole picture of a vision, planning and long term goals which a company needs in order to ready itself for ERP implementation. They consist of:

- Top management support
Top management must be seen as a participant in the implementation and provide the necessary resources. [11].
- Business plan and vision
There should be a justification for investment on ERP system based on business goals and needs [1].
- Clear understanding of strategic goals
There must be clear definitions of goals, expectations. Organization must also carefully define why the ERP system is being implemented and what critical business needs the system will address [12].

- **Project champion**
There is a need to have a project champion who possesses strong leadership skills as well as business, technical and personal managerial competencies during the ERP project implementation to handle organizational change [6].
 - **Change management**
The effective implementation of an ERP system requires a management change to prevent forces of resistance. Training and education is an important process in change management [10].
 - **Organizational culture**
When the system conflicts with an organization's culture, resistance behavior will result: the system will be rejected, sabotaged or modified to match the existing culture. Leadership can enhance the chance of ERP success by fostering a desired culture [13]
 - **Budget**
The nature of ERP implementation is such that there are usually unforeseen and unexpected occurrences that increase the overall costs. Therefore, a loose budget policy is recommended [6].
 - **Top management awareness**
Top management should be aware of the project goals and complexity, labor required, existing limitations, required capital investment and project inevitability [14].
- Tactical Factors:** Tactical factors are those that present essential methods and techniques that a company needs to be ready for ERP implementation. They consist of:
- **Business process reengineering**
BPR results in a complete description of how a business will operate after the package is in use with the overall objective of matching the goals/requirements to the implemented system [6].
 - **Project team composition**
There is a need for an implementation team that spans the organization as well as one that possesses a balance of business and IT skills [6].
 - **Effective communication**
Clear and effective communication at all levels of an organization is necessary before and during the ERP implementation and influence the acceptance of technology in an ERP implementation environment [10].
 - **Project team empowerment**
This concept refers to the need for the team to be empowered to make necessary decisions in due time [6].
 - **Team motivation**
It is important that the team leader create a stimulating work environment. This results in a high level of staff retention [6].
 - **Use of consultants**
Consultants may have experience in specific industries, comprehensive knowledge about creating modules and may be better able to determine which suite will work best for a given company [14]
 - **Crisis management**
Project team of ERP implementation should have skill of risk/crisis management to deal with the problems during the project implementation.
 - **Education and Training**
There is a need for training both project team and users [6]. So, top management should provide sufficient time and money that are needed for training before and during ERP implementation.
 - **Steering committee**
To make ERP successful, it is necessary to form a steering committee which enables senior management to directly monitor the project team's decision making [14].
 - **Interdepartmental cooperation**
A key factor for the successful implementation of ERP systems is a corporate culture that emphasizes the value of sharing common goals over individual pursuits and the value of trust between partners, employees, managers and corporation [14].

- **Effective project management**
Project management is important in several aspect: having a formal implementation plan, a realistic time frame, having periodic project status meetings, having an effective project leader who is also a champion and having project team members who are stockholders [11].
- **User involvement**
User involvement in the stage of definition of company's ERP system needs and its implementation is effective because it enhances perceived control of users [11].

Operational Factors: Operational factors are the factors that are related to existing operational systems of the company and consist of:

- **IT infrastructure**
It is critical to assess the IT readiness of the organization, including the architecture and skills. If necessary, infrastructure might need to be upgraded or revamped [6].
- **Project team competence and involvement**
There is a critical need to put in place a solid core implementing team that is comprised of the organization's best and brightest individuals. There should be a commitment to release these individuals to the project on a full time basis [6].
- **User characteristics**
The characteristics of different users may affect the ERP implementation success including education levels, characters, technical-oriented or business –oriented, etc [8].
- **Data accuracy**
Because of the integrated nature of ERP, data accuracy is absolutely required for an ERP system to function properly. Educating users on the importance of data accuracy and correct data entry procedures should be a top priority in an ERP implementation [12].
- **Availability of the internal and external consultants**
it is important for companies to have in-house professional IT experts or can afford outside expertise to solve technical complexity [15].

- **Organizational experience of similar scale IT or organizational change projects**
Organizational experience of similar scale IT or organization change project affect the success and acceptance of new system also the project team members' experience gained during former information systems implementation affect successful ERP implementation.
- **Legacy system considerations**
There must be consideration of the current legacy system in place as this could directly affect the technical and organizational change required. Whether or not there is a reasonably well working manual system in place is another consideration [6]

Methodology: The steps taken for the methodology of this study were as follow:

- Determination of research framework and the major factors.
- Developing a questionnaire for determining the Fuzzy (IF-Then) Rules with respect to the three main factors stated in the framework as inputs and ERP readiness as output. Validity and reliability of the questionnaire was confirmed and they were distributed among the ERP practitioners. Fuzzy rules as the basis for determination of the conditions of the company have been formed and entered into Fuzzy system through MATLAB software.
- Identifying the membership functions for each input and output variable in (0, 1).
- To determine the value of each factor, different questionnaire was prepared to collect related information of the status-quo of the company. Also validity and reliability of mentioned questionnaire was confirmed and it was distributed among managers and experts in that company. Calculated mean obtained from questionnaire results has been inputted to the Fuzzy System.
- Final results were analyzed and the readiness of the company for implementing ERP was determined by this software.

This study has used a” Fuzzy IF-Then” Rules based method to assess the readiness of the company for implementing ERP. One of the key factors of the success of Fuzzy system is the ability to incorporate human/expert

Table 1: The number of the questions related to the three factors

	Strategic factors	Tactical factors	Operational factors
Number of questions	38	36	28
Percent	% 37	% 35	% 27

Table 2: The results of calculations for the strategic factors

Business plan and vision	0.51
Clear understanding of strategic goals	0.40
Project champion	0.57
Change management	0.46
Organizational culture	0.41
Budget	0.50
Top management awareness	0.30
Mean of strategic factors	0.45

Table 3: The results of these calculations for the tactical factors

Business process reengineering	0.51
Project team composition	0.47
Effective communication	0.38
Project team empowerment	0.50
Team motivation	0.47
Use of consultants	0.45
Crisis management	0.37
Education and Training	0.37
Steering committee	0.60
Interdepartmental cooperation	0.58
Effective project management	0.46
User involvement	0.41
Mean of tactical factors	0.46

Table 4: The results of these calculations for the operational factors

IT infrastructure	0.43
Project team competence and involvement	0.60
User characteristics	0.50
Data accuracy	0.53
Availability of the internal and external consultants	0.53
Organizational experience of similar scale IT or organizational change projects	0.47
Legacy system considerations	0.60
Mean of operational factors	0.52

knowledge, where information is described by vague and imprecise statements. In addition, the behavior of a Fuzzy Inference System (FIS) is expressed with a language that is easily interpretable by human. One of the easiest approaches to construct a FIS-based assessment model is to assume attribute(s) to be input(s) of the FIS and measuring index as output(s) of the FIS. The relationship between attribute(s) and measuring index is described by Fuzzy IF-Then Rules [16].

Case Study: In this study, we applied the research framework in a famous Iranian automaker company (Bahman Motor). This company has ISO 9000 standard and it has also access to intranet network. The company systems consist of: 1- Financial: salary and wage, fixed assets, budget, financial accounting, industrial accounting, order accounting 2- Administrative: personnel system 3- Engineering: CAD and CAM 4- Sale and 5- Productive: maintenance and repair, warehouses, projects control, production control and planning, orders control, management control, purchase, BOM, waste control and output control.

Data Analysis: To collect information about status-quo of the company, we designed a 102 questions questionnaire. The questions were related to the strategic, tactical and operational factors. Table 1 shows the number of questions related to each factor. These questions have been divided into 6 categories (management, human resource, project managers, R and D, design and planning and financial department) in regard to expertise of the employees of the company.

After collecting data, the value of each subcategory of strategic, tactical and operational factors were determined through mean calculations. Then, the value of each factor was determined by finding the mean of their subcategory's value. The results of these calculations for the factors are presented in Tables 2, 3 and 4.

According to the calculations, the value of strategic, tactical and operational factors equals to 0.45, 0.46 and 0.52 respectively in (0, 1). These values were entered into MATLAB software as input variables and converted to Fuzzy numbers with the membership functions which was defined for each variable.

Figure 2 illustrates the Fuzzy system of assessing the readiness of the company for ERP implementation in MATLAB software and Figure 3, 4, 5 and 6 illustrates the membership functions which were defined for each input and output variable.

The type of membership function and its parameters were determined by consulting ERP experts. For the sake of simplicity, this case has used 3 lingual labels (low, medium, high) for membership function of each variable.

According to the value of each factor and limit of the lingual labels in membership functions, strategic factors are placed into medium fuzzy set. Tactical and operational factors are also placed into medium fuzzy set.

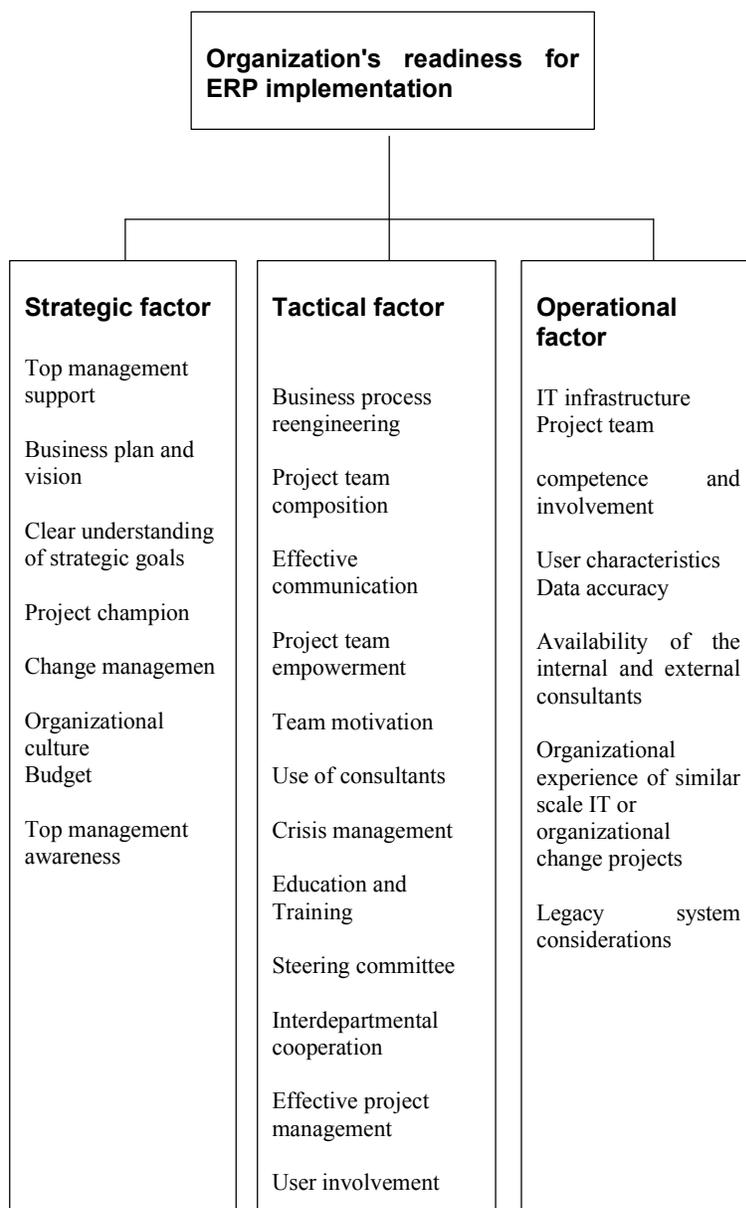


Fig. 1: Organization's readiness for ERP implementation

Fuzzy rules should be formed by consulting with ERP practitioners and their results will be entered into knowledge base of Fuzzy system. Then, the Fuzzy system will draw a conclusion based on the Fuzzy rules and the value of three factors. Readiness of the company for ERP implementation will be determined as output of inference engine of the Fuzzy system.

In order to design a Fuzzy system by MATLAB software, there are X lingual variables with Y lingual labels. Thus, there are Y^X rules in the system. Lingual labels are Fuzzy sets that will be defined with membership

functions. For example, if $i=1, 2, 3, \dots, n$ and A_i is the factor that is influenced in readiness of the company for ERP implementation and C_i is the lingual value of each factor. Then, the Fuzzy rules will be as:

$$A_i \text{ is } C_i \text{ AND } \dots \text{ AND } A_n \text{ is } C_n \text{ THEN } A_{org} \text{ is } C_o$$

A_o is lingual value of an organizational variable (ERP readiness) and all C_i and A_o are Fuzzy sets. In this study, 3 lingual variables (strategic, tactical and operational factors) and also 3 lingual labels (low, medium and high)

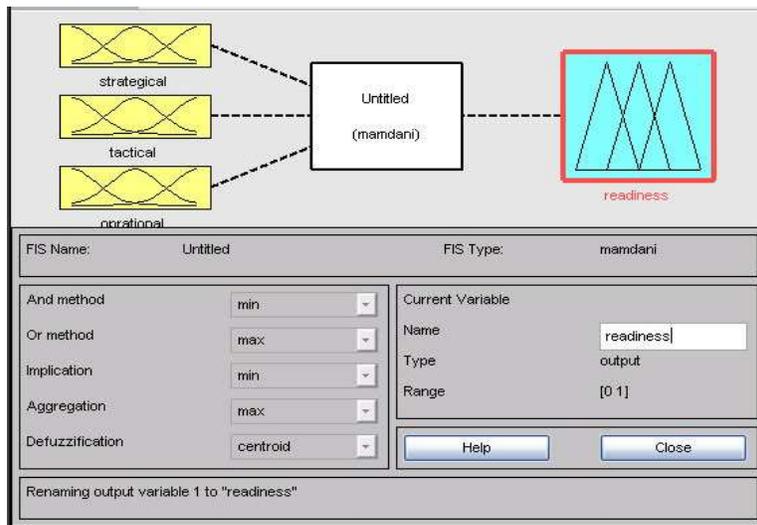


Fig. 2: The Fuzzy system of assessing the readiness of the company for ERP implementation in MATLAB software

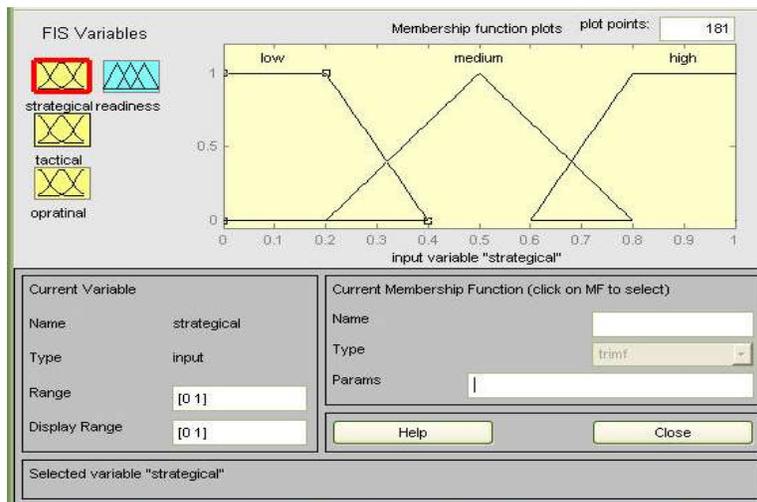


Fig. 3: Membership function for strategic factor

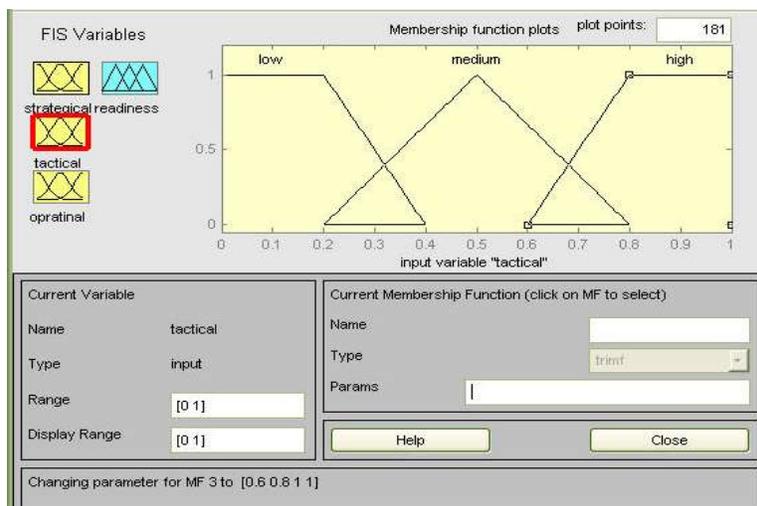


Fig. 4: Membership function for tactical factor

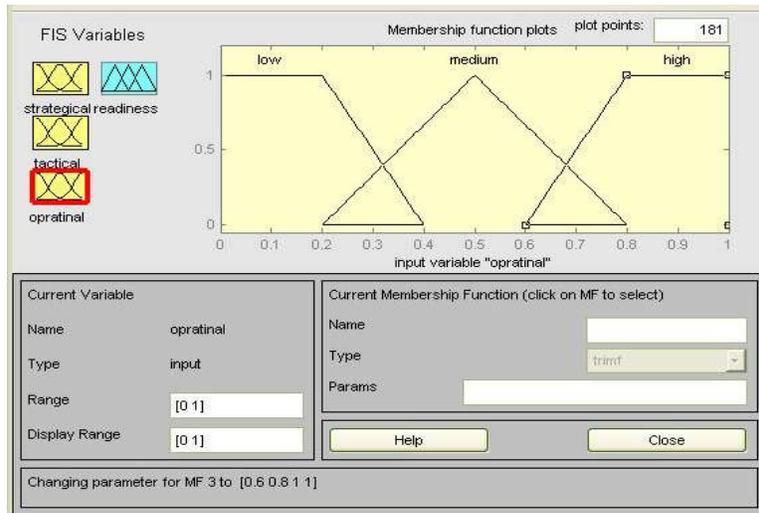


Figure 5: Membership function for operational factor

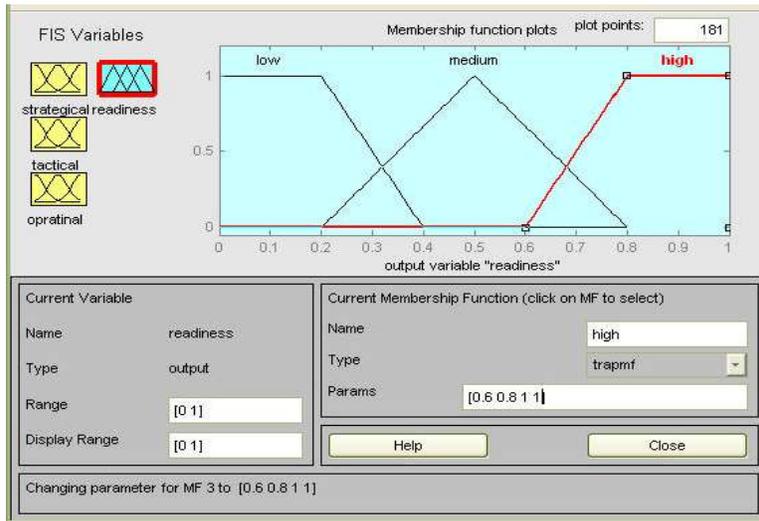


Fig. 6: Membership function for output variable

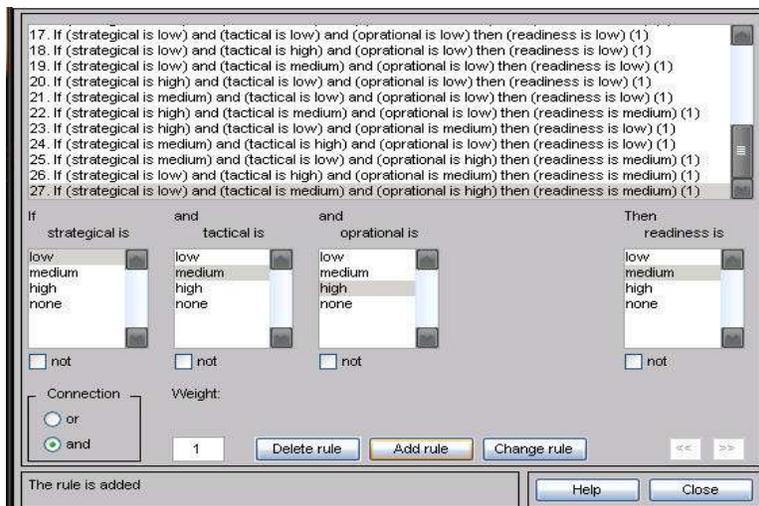


Fig. 7: Fuzzy rules in knowledge base in MATLAB software

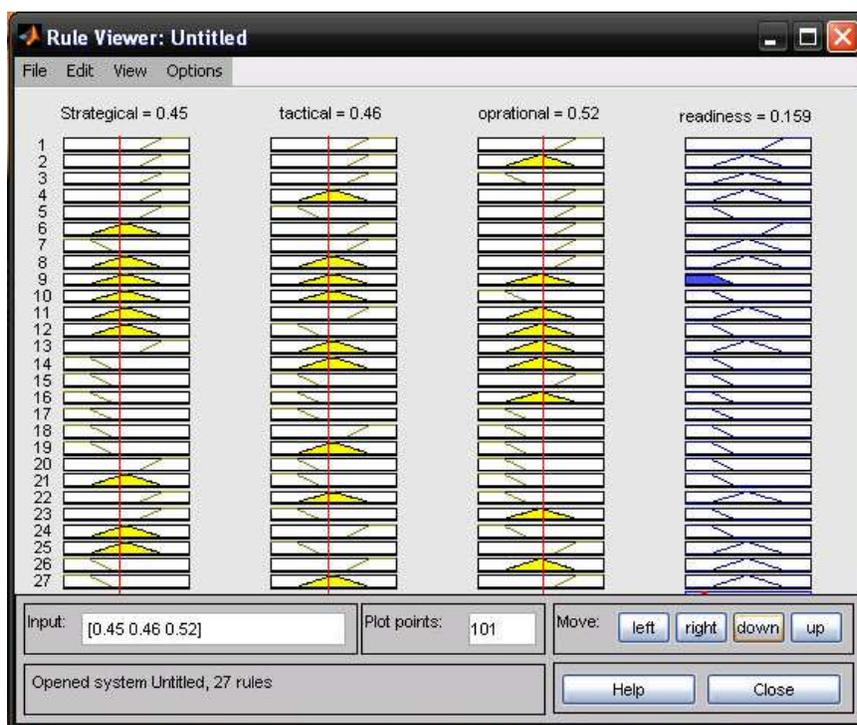


Fig. 8: Drawing a conclusion in Fuzzy system

for each variable have been defined for Fuzzy system. Thus, there are 27 Fuzzy rules in the system. Moreover, Justification of these Fuzzy rules was evaluated. Figure 7 shows the Fuzzy rules in knowledge base in MATLAB software. Finally, result of the Fuzzy system as a fuzzy number will be determined and then the fuzzy number is defuzzified with a defuzzifier like center of gravity defuzzifier and is converted to a real number.

Figure 8 shows a conclusion in Fuzzy system. The real value of output variable for this company has been determined 0.15 in [0 1].

According to the value of output variable and limit of lingual labels in membership function, readiness of the company for ERP implementation resides in Fuzzy low set. That means Bahman motor's readiness for ERP implementation is low.

CONCLUSION

According to calculations, the value of first input variable (strategic factors) in Bahman Motor is determined to be 0.45 in [0 1] and the value of second and third input variable (tactical and operational factors) in that company are 0.46 and 0.52 in (0, 1). According to membership functions identified in software for input

Table 5: Results of the study

Variables	Real number	Fuzzy set
Strategic factors (input)	0.45	medium
Tactical factors (input)	0.46	medium
Operational factors (input)	0.52	medium
Readiness for ERP implementation (output)	0.15	low

variables, they are assessed medium for Bahman Motor. Finally, the value of output variable (company's readiness for ERP) is calculated to be 0.15 in (0, 1) by inference engine in fuzzy system that according to membership function identified for output variable, it is assessed low for the company. The results of the study are summarized in Table 5.

Due to intense competition in Iran's auto industry, Bahman Motor is forced to improve its processes and implementing ERP. But results of the research show that the readiness of the company for ERP is low, which means the company is operating very weak in many aspects related to ERP system. Therefore, the company should make suitable plans about all factors identified in the research framework. The company should use the related experts and consultants to enhance the company's readiness for a successful ERP implementation in future.

Current research has assessed the value of the main factors which are essential for ERP implementation in a company, but it has assumed similar weight for all factors and subcategorizes. So, the discovery of the weight or priority of the factors in companies which have implemented ERP will be helpful and will lead to a more precise planning for a successful implementation in companies that decide to do so.

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