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ASSESSMENT OF THE EFFECTIVENESS OF ERP SYSTEMS BY A FUZZY LOGIC APPROACH

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ABSTRACT

In today's intensely competitive business world, there is an increasing demand for Enterprise Resource Planning (ERP) systems. This is because there is an essential need for efficient ways of continuous assessment, identifying shortcomings and improving system performance. On one hand, the quality of ERP systems is related to the user satisfaction. On the other hand, measuring human's satisfaction is intermingled by uncertainty and vagueness. That is why ordinary statistical analysis is not necessarily efficient in this context. This motivated us to use fuzzy logic methods in assessing the effectiveness of ERP. We conducted this research in an Iranian company producing automobile parts. We also used Ifinedo & Nahar's model for the assessment of ERP effectiveness. We had interviews with the employees, managers and experts. Then we analyzed the collected data using MATLAB©. Our analysis showed that ERP effectiveness in the company is fairly good.

Keywords: Enterprise Resource Planning (ERP); Information System (IS); Effectiveness; Fuzzy Logic; Fuzzy Inference

INTRODUCTION

An Enterprise resource Planning (ERP) system is a packaged business software that integrates organizational process and functions into a unified system[5;6] Many researchers and practitioners agree that Enterprise Resource Planning (ERP) systems are the most important development in terms of corporate use of information technology(IT) in the 1990s [2]. Davenport was quoted as saying" integrated information system is a smart tool that can be used by a firm to solve problems associated with widely distributed information sources. In decades, adopting an enterprise resource planning (ERP) system has been a promised way for corporation to gain competition advantages in the world [8]. For instance, ERP system can integrate the corporation internal information such as finance, accounting, purchase and so on to achieve proper information in the proper time. Enterprise Resource Planning (ERP) systems can integrate a firm's internal information from a financial perspective, allowing finance, accounting, purchasing and other departments to acquire information in a timely manner. It plays an important role in establishing a firm's

competitive advantage[1].The latest generation of ERP commercial software packages often integrate information from finance, accounting, human resources, operations, supply chains, and customers[7].

ERP systems are being adopted for a variety of reasons, including the replacement of legacy systems and cost reductions [9].So it is required to assess this system permanently to accomplish the goals of implementing ERP. In the literature of information system, the quality of information system can be examined on the basis of user satisfaction. Also satisfaction can be considered as a general criterion. Unlike classical logic, fuzzy logic is appropriate for solving complicated issues with imprecise model parameters and structure. As stated before, effectiveness can be evaluated based on user satisfaction. Totally the assessment of ERP systems effectiveness is interrelated to user satisfaction, individual attitude, human impressions' which all have complexity and uncertainty. Unfortunately, in these kinds of cases quantitative conventional methods are not responding. Some reasons for this claim are as follows: more qualitative information than quantitative ones, incomplete criteria and measures, opposing definitions and comprehensions, high risk and uncertainty, high cost of access to accurate information [3].

In this paper we would like to consider ERP effectiveness of an Iranian company. by the means of fuzzifying a model introduced by Ifinedo in 2006[6].This case is focused on an Iranian manufacturing company producing automobile parts.ERP system was implemented from the SAP software package 3 years age.

MODEL

Here, we use the model introduced by Ifinedo & Nahar in 2006 [5]. Different dimensions of this model are:

1.System Quality (SQ)
2.Information Quality (IQ)
3.Individual Impact (II)
4.Organizational Impact (OI)
5.Workgroup Impact (WI)
6.Vendor/Consultant Quality (VQ).

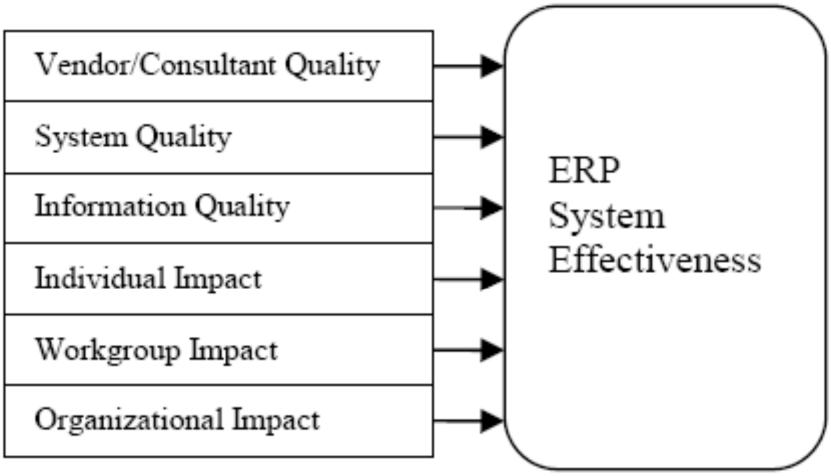

Figure 1: ERP system effectiveness assessment model

METHODOLOGY

While organizations compete in a completely different conditions and cultures and their employees have special characteristics, current models for assessing the quality of ERP are not universal. So some changes to each model are required. It is believed that preparing a unified and universal model is not feasible. So for confirming the validity of model in the context of this company, we made some appointments and did group interviews with SAP group in mentioned company. This group is made up of 5 managers and assistants of MIS department of organization and 9 managers of departments in which modules of SAP are being used. In addition, because the main questionnaire was in English, we had no choice but to redefine each variable clearly.

Given the modified indicators, questionnaires on the scale of 0 to 1(0 means strongly disagree, 1 means strongly agree) were prepared and distributed among ERP users, managers of those users and chief officers. All the collected data for each dimension were average. From onwards, we tried to solve the problem by fuzzy approach.

FUZZY EXPERT SYSTEM

A fuzzy expert system is simply an expert system that uses a collection of fuzzy membership functions and rules. The form of rules in a fuzzy expert system is as following: If A is not bad and B is excellent, then C is good.

There are seven main steps in developing a fuzzy expert system [4]:

1. Problem definition
2. Definition of linguistic variables
3. Definition of fuzzy charts
4. Definition of fuzzy rules
5. System structure
6. System examination
7. System arrangement

1. Problem definition

The purpose of this paper is to apply fuzzy inference in the assessment of effectiveness of ERP systems in automobile parts manufacturing company with Ifinedo & Nahar's model. It is good to know that as Ifinedo's findings show,ERP effectiveness has six components. We categorized them into two separate dimensions called ERP Impact and ERP Quality. The indicators of those six components are assessed through questionnaire.

2 & 3. Definition of linguistic variables and fuzzy charts

Our linguistic variables are ERP effectiveness, ERP Quality (SQ, VQ and IQ) and ERP Impact (II, WI and OI). We defined their linguistic values by doing interviews with ERP experts. The aim was to figure out our universal set. We took into consideration the ERP effectiveness as a fuzzy set with 7 linguistic values such as: very good (VG), good (G), not good (NG), average (A), not bad (NB), bad (B), very bad (VB). The membership function is triangular.

We consider ERP Quality & ERP Impact's dimensions as a fuzzy set with 5 values called: very high (VH), high (H), satisfactory (S), low (L), very low (VL) with triangular membership function.

Also we defined each component of ERP Quality and ERP Impact with linguistic values of Excellent (E), Moderate (M), and Weak (W) in terms of a trapezoid shape of membership function.

Knowledge base

The assessment of effectiveness of ERP systems is required to implement 4 phases of fuzzy logic inference and approximate reasoning. Firstly, we assumed the average of relative indicators as the input of next phase. In the first and second phase of inference we got ERP Quality dimension by combining the three components VQ, SQ and IQ components. Also by combining the next three components (WI, II and OI) we got ERP Impact dimension. In the third phase of inference we had the final ERP systems effectiveness by combining ERP Quality and ERP Impact dimensions. Figure 2 shows different phases of inference and the original model used.

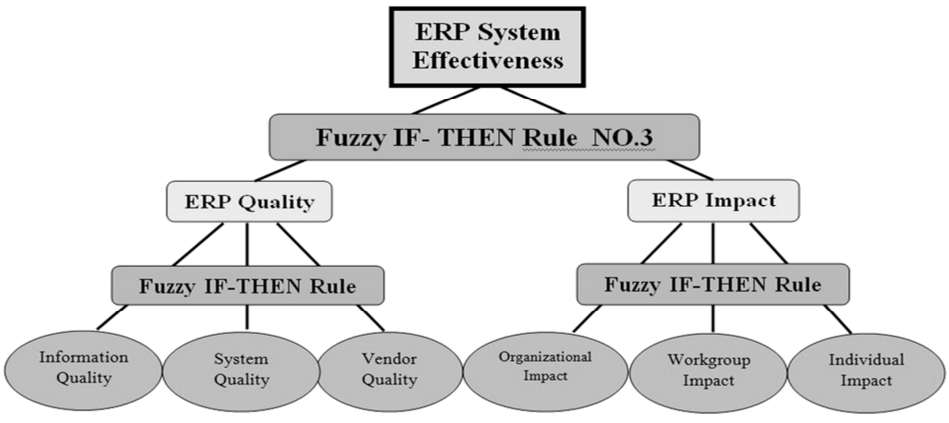

Figure 2: Different phases of inference and the original model

As you follow the model, the real data are just available for the indicator level of the model's variable. To follow up, we elaborated on matching fuzzy sets with dimensions and components of final indicators of effectiveness, logical rules and phasal inferences of ERP effectiveness. Then we implemented them in the MATLAB's fuzzy logic "Tool Box" and did the approximate reasoning.

4. Definition of If, then fuzzy rules

The most essential issue in the expert system is building rules for system. We conducted some interviews with ERP experts to extract current rules in this research. Totally we came to these three rulebases:

1. ERP Quality inference rulebase comprises of IQ, VQ and SQ components as inputs. For example: If VQ is excellent and IQ is weak and SQ is moderate, then ERP Quality is satisfactory.
2. ERP Impact inference rulebase comprises of WI, II and OI components as inputs.
3. ERP effectiveness rulebase is obtained from ERP Quality and ERP Impact. For example: If ERP Impact is satisfactory and ERP Quality is high, then ERP effectiveness is not bad.

5 & 6 & 7.Building, test and adjustment of systems

First, we define fuzzy charts in MATLAB software. Then let's turn our attention to ways of inference.

In order to infer and defuzzifire we used "Mamdani technique" and "Center of Gravity(COG)" which both were by default in MATLAB software. In the next phase the confirmed rules based on expert's attitudes were put into the rulebase of software.

FUZZY INFERENCE

In this section we explain fuzzy inference based on data gathered. Numbers shown in Table 1 are representative of the average model's indicators. These numbers were determined by the interviewees answered questionnaires based on spectrum ranging from 0 to 1(0=strongly disagree, 1=strongly agree).

FUZZY INFERENCE PHASES

1. Fuzzification
2. Inferenced rules and fuzzy charts
3. Defuzzification [4]

The fuzzy inference whole process is shown in Figure 3.

Table 1: Data gathered for ERP system effectiveness

ERP SYSTEM EFFECTIVNESS					
ERP Quality			ERP Impact		
Information Quality	**System Quality**	**Vendor Quality**	**Organizational Impact**	**Workgroup Impact**	**Individual Impact**
Measure Indicator	**Measure Indicator**	**Measure Indicator**	**Measure indicator**	**Measure indicator**	**Measure indicator**
0.516 Up to date information	0.675 Accurate data	0.556 Adequate technical support	0.412 Reduces cost	0.645 Improve worker participation	0.378 Improve Creativity
0.732 Timely information	0.471 Flexible	0.473 Credible & trustworthy	0.603 Improve productivity	0.487 Organizational wide communication	0.405 Improve Learning
0.564 Understandable information	0.545 Easy to use	0.650 Good relationship	0.213 Enable e-business	0.513 Inter departmental communication	0.745 Increases Productivity
0.456 Important information	0.551 Easy to learn	0.775 Experienced &good training	0.675 provide competitive advantage	0.312 improve responsibility	0.467 Beneficial for task
0.360 Brief information	0.543 Reliable	0.658 Communication well	0.583 increase customer service	0.645 efficiency of sub-unit	0.677 Enhance decision Quality
0.651 Relevant Information	0.620 Data integration		0.417 facilitate sbusiness process change	0.647 improve productivity	0.458 Save time
0.673 Useable information	0.494 Efficient		0.442 support decision making	0.513 enhance solution efficiency	
	0.229 Allow for customization		0.789 better use of data resource		
	0.342 Good features				
	0.565 Integrate with other system				
	0.324 Meets users requirement				
0.566	**0.487**	**0.6221**	**0.517**	**0.538**	**0.521**

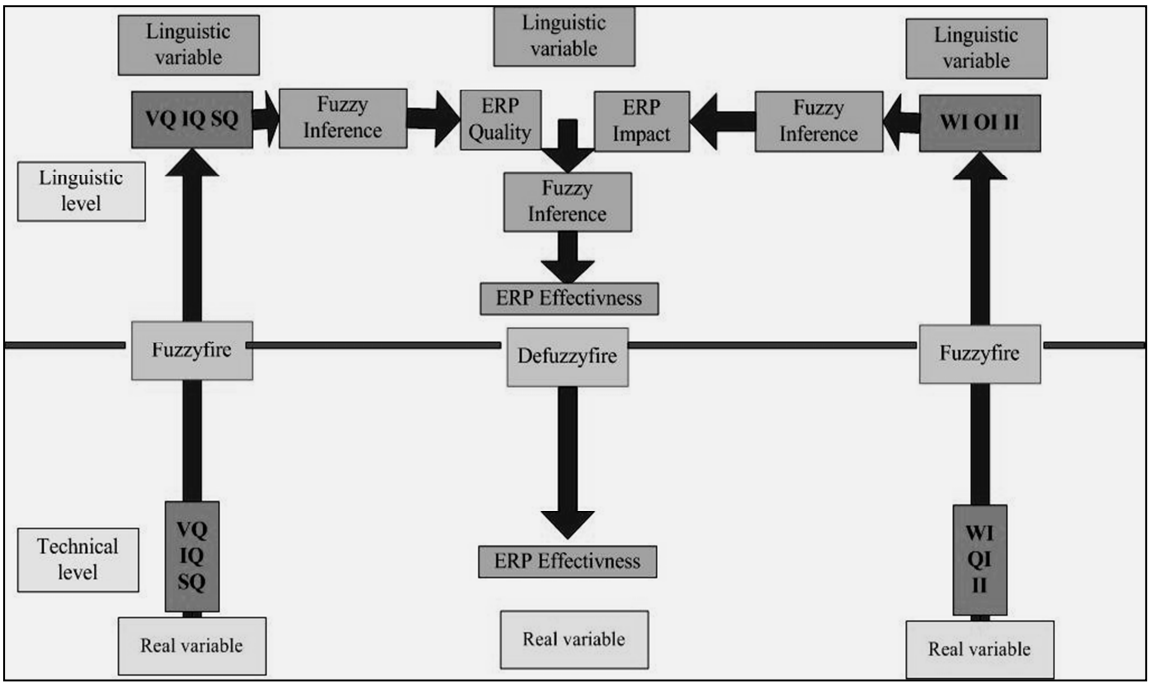

Figure 3: The whole fuzzy inference process

As you have seen above, technical level variables are known as Real Variables (VQ, IQ, SQ, WI, QI, and II) and move towards linguistic level through fuzzification and become linguistic variables. In this phase fuzzy inference is implemented based on existing rules therefore the amount of ERP Quality and ERP Impact will be inferenced. Then the inference was done on the basis of knowledge base rules. The result is the amount of linguistic variables of ERP effectiveness. In the last phase, defuzzification was carried out using Center Of Gravity (COG).Details are mentioned below.

1. Fuzzification

This is a process in which real variables are converted into linguistic ones. In our case, all the inputs consisting of the average of indicators of the six components' model variables (SQ, VQ, IQ, WI, OI, and II) are fuzzified. First applied each input into the MATLAB tool box and each one of the fuzzy charts (Figures 4-6). We explain SQ fuzzification as an example. As you can find below, the input number for SQ is 0.487 that is moderate equaled to 95% and weak equaled to 5%.

What is meant by 0.487 for SQ variable is that:"System quality is fairly moderate".Fig.5 shows this process for IQ and VQ, respectively. For IQ the input number is 0.566 that is moderate equaled to 85% and excellent equaled to 15%.The input number for VQ is 0.822 that is moderate equaled to 33% and excellent equaled to 67%.

2. ERP Quality fuzzy inference rules and charts

All the phases of ERP Quality fuzzy inference are shown in Figure 7. After implementing each rule, we added the results of all 27 rules to each other then ERP Quality charts shown in the last column are obtained.

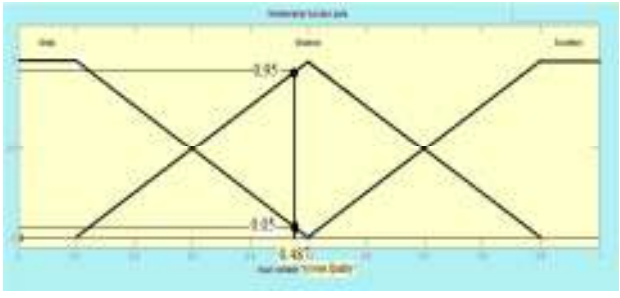

Figure 4: System Quality (SQ)

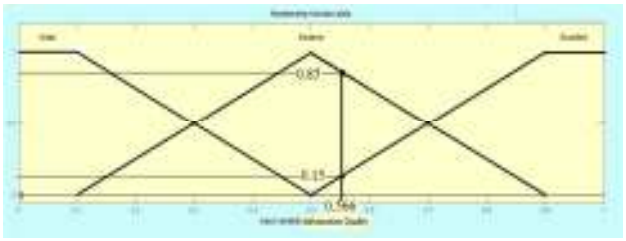

Figure 5: Information Quality (IQ)

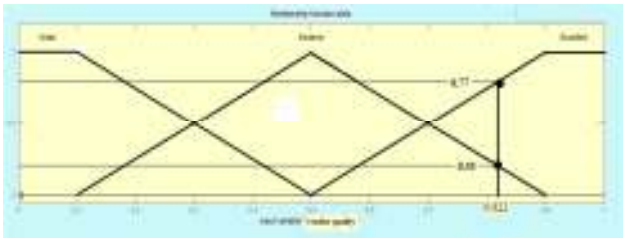

Figure 6: Vendor Quality (VQ)

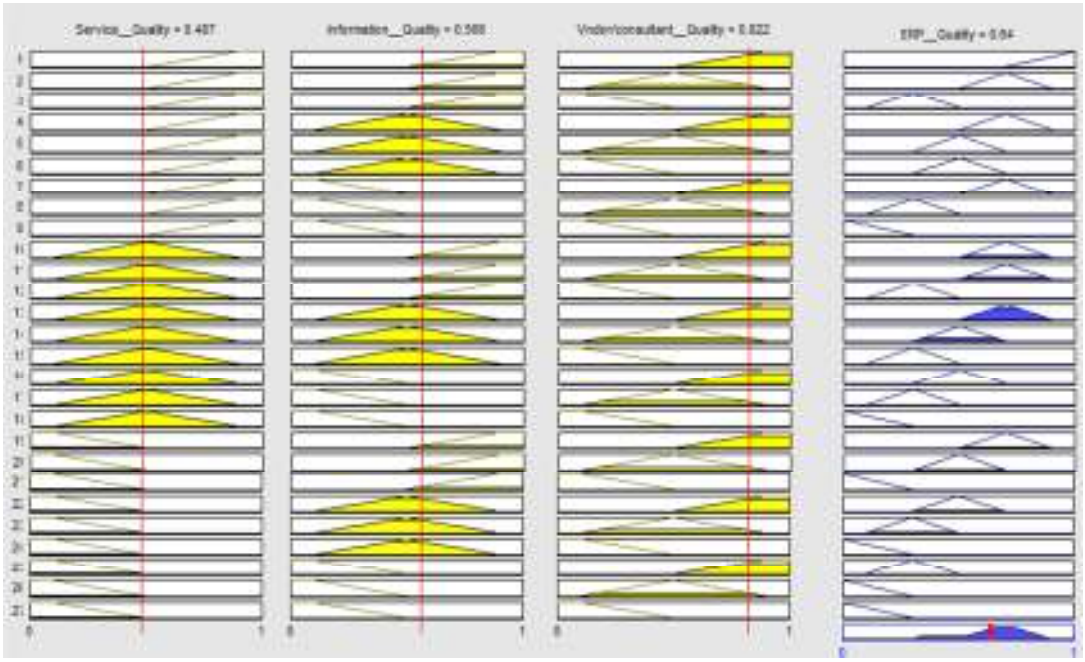

Figure 7: ERP Quality Fuzzy Inference

3. Defuzzification

In this phase, we calculated the numeral amount of each chart by Center Of Gravity (COG) method and the following formula with MATLAB.

$$\int \frac{XF(X)}{F(X)}\,dx$$

Formula 1: Formula for calculating COG

The calculated quantity for ERP Quality and ERP Impact components are 0.64 and 0.604, respectively.

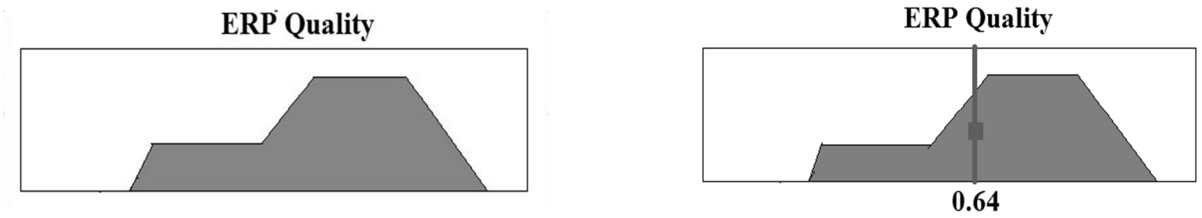

Figure 8: Final membership function in ERP Quality

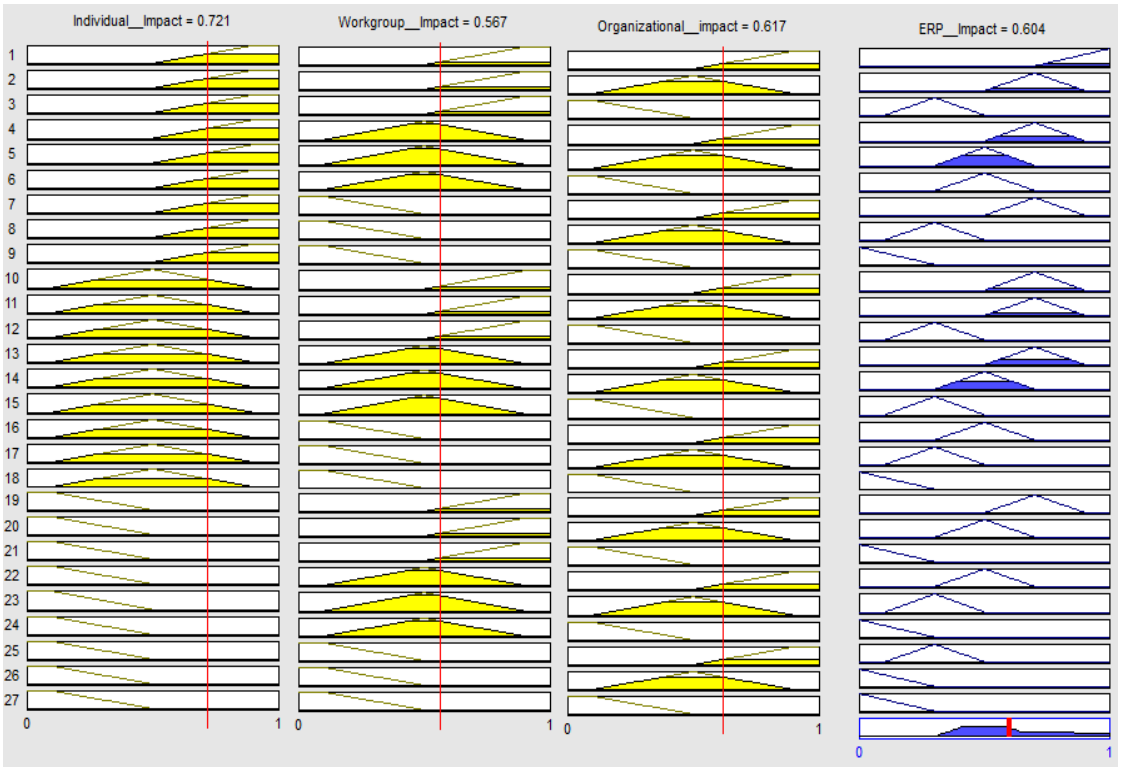

Figure 9: ERP Impact fuzzy Inference

ERP EFFECTIVENESS FUZZY INFERENCE

ERP Quality fuzzification

The input number for ERP Quality is 0.46.By applying this number to ERP Quality chart; the numeral amount will be fuzzyfied. This means:"System Quality is fairly high"

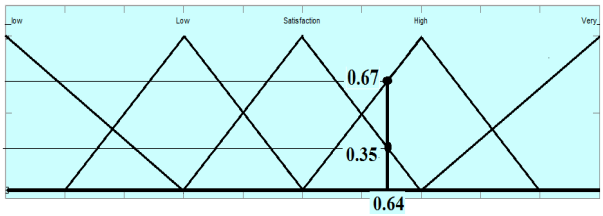

Figure 10: ERP Quality membership function

ERP impact fuzzification

The input number for ERP Impact equals to 0.604.By applying this amount to ERP Impact chart, the numeral amount will be fuzzyfied. This means:"The ERP Impact is satisfactory" or "ERP Impact is high"

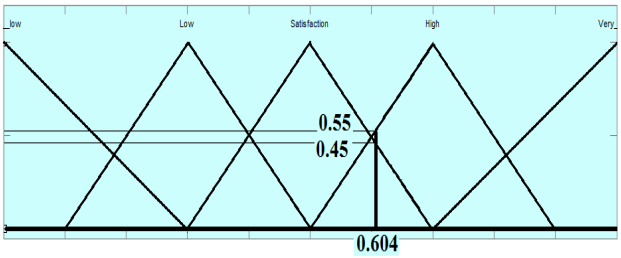

Figure 11: ERP Impact membership function

ERP effectiveness

This phase was done by Mamdani method (Max-Min).The minimum or the area under each fuzzified chart is the input for ERP effectiveness inference. Following combining ERP effectiveness membership functions with the COG method, the quantitative amount for ERP effectiveness is 0.673.

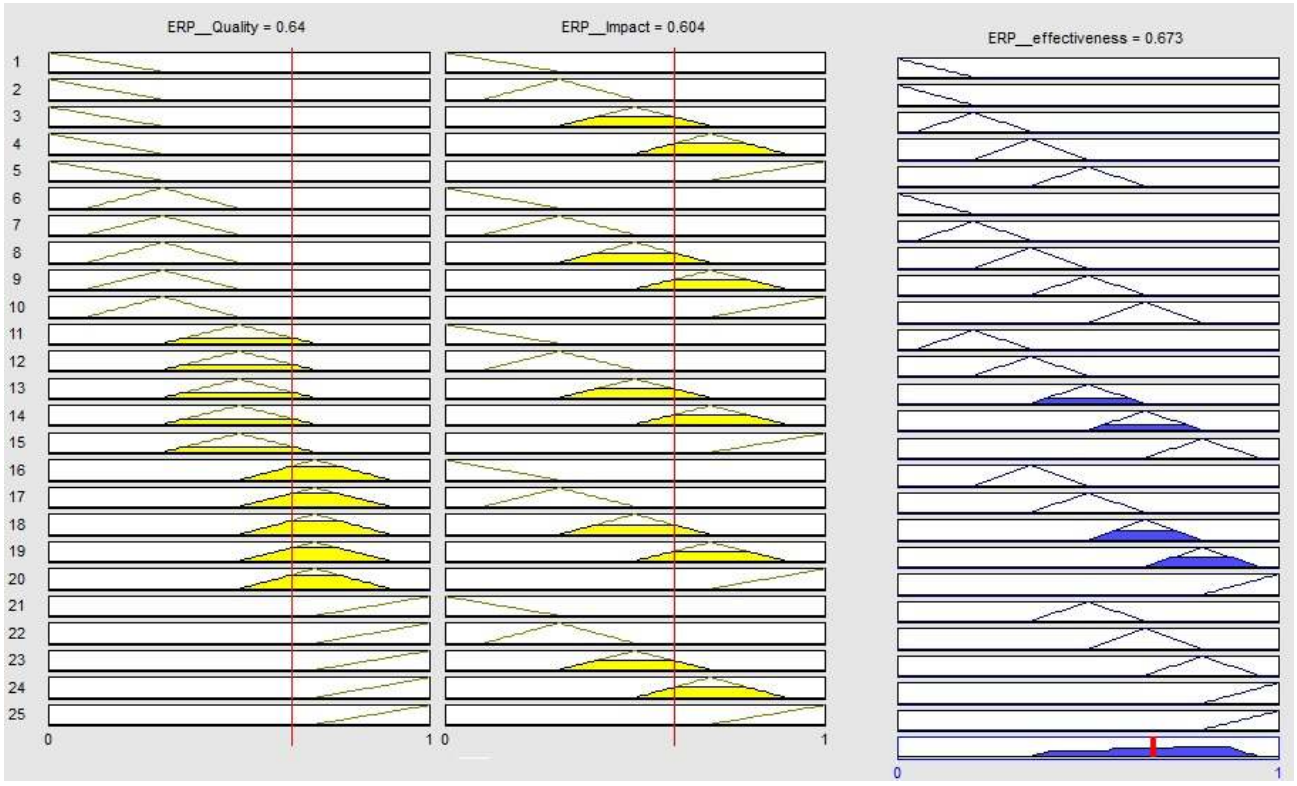

Figure 12: ERP effectiveness fuzzy Inference

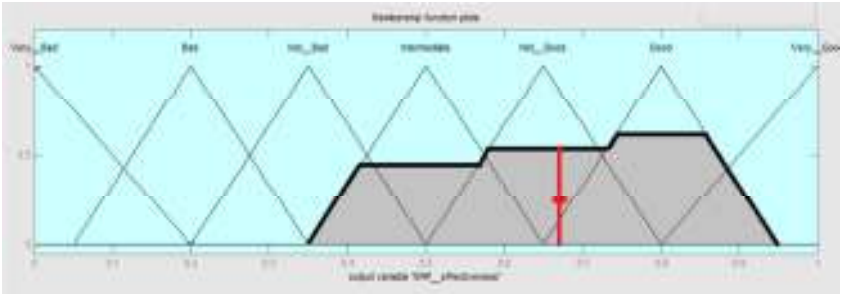

Figure 13: ERP effectiveness membership function

CONCLUSION

As ERP effectiveness is interrelated to user satisfaction, we decided to measure that variable by Fuzzy logic approach in a company producing automobile parts based on Ifinedo & Nahar's model. We implemented MATLAB software in this research. The above mentioned results and figures show that ERP effectiveness is fairly good in this case.

RESEARCH LIMITATIONS

The most important limitation in this research was arranging meetings and interviewing experts. Since the quality of research was our priority, we spent much time on this regard.

FUTURE RESEARCH

It is suggested that this research be done in the other organizations even industries because dimensions of user satisfaction are case dependent. By doing this, after some time we can demonstrate the ERP effectiveness in IRAN. Also, AHP method can be replaced by fuzzy logic.

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