Identifying and Prioritization Effective Factors in MRP implementation Using FAHP Approach

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Abstract: MRP is a plan for the production and purchase of the components used in making items in the master production schedule. It shows the quantities needed and when manufacturing intends to make or use them.MRP is a commonly accepted approach for replenishment planning in major companies (Gharakhani et al., 2011). Implementation of any production system requires that all of the factors identified in its implementation and also determine the importance of each. In this study the researcher to identify and prioritize the Effective Factors in MRP implementation. The survey results show that the most important Effective Factors in MRP implementation are Top management support and Formal project planning. Moreover, the less important factor is software / hardware Characteristics.

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1. Introduction

MRP was first introduced in 1970's; thereafter, many researchers, papers, books, industries, companies and even different sciences have applied it (Dolgui et al., 2007). In manufacturing environments with complex product structures and multiple production stages, material requirements planning (MRP) systems are the most commonly used for production planning and material supply decision making. In some researches, the advantages and disadvantages of MRPs have been explained. (see Safizadeh et al., 1986; Harhen, 1988 ; Browne et al., 1996). Material requirement planning (MRP) is deployed in order to model integrated business systems. MRP is a computer-based information system designed to handle ordering and scheduling of inventories (e.g. raw materials, component parts, and subassemblies). It has been designed primarily for complex production planning environments. Significant benefits such as improved customer service, better production scheduling, and reduced manufacturing costs are some of the key benefits. MRP has evolved from a simplistic representation in the 1980s to today's powerful and comprehensive versions, i.e. manufacturing resource planning (MRPII) and enterprise resource planning (ERP).

In MRP systems, the master production schedule (MPS) represents a plan for the production of all end-items over a given planning horizon. It specifies how much of each end-item will be produced in each planning period, so that future component production requirements and materials purchases can be calculated using MRP component- explosion logic. As such, the MPS has to be feasible so that components can be produced within the capacityavail able in each time period. It is clear that there is a role here for a planning tool that efficientlytakes capacityand the MRP explosion into account at the same time, a point made by Shapiro (1993).

MRP determines the quantityand timing of the acquisition of dependent demand items needed to satisfy master schedule requirements. One of its main objectives is to keep the due date equal to the need date, eliminating material shortages and excess stocks. MRP breaks a component into parts and subassemblies, and plans for those parts to come into stock when needed. MRP relates each component or subassemblyto every other part and to the component as a whole. With computer technologyadvances, maintenance and repairs have become integrated within the system. MRP is sold for manufacturing applications, but it could potentiallybe useful in aircraft parts inventory. Material Requirements Planning (MRP) has fallen into disfavor during the last ten years, as demonstrated by the extensive literature and conference material coming out of organizations like the American Production and Inventory Control Society (APICS) which discuss its shortcomings (Berger, 1987). MRP has received intense challenges of its e€ectiveness from Japan. In batch manufacturing environment, material requirements planning (MRP), manufacturing resource planning (MRPII) or enterprise resource planning (ERP) has been recommended as the ideal system. Since the MRP release logic is deployed in MRPII and ERP systems, when they are used for production planning and scheduling, the scheduled outputs are identical. This research focuses on their roles in production planning and scheduling, therefore the use of these systems in batch manufacturing enterprises is referred as MRP-controlled manufacturing environment. The Materials Requirements Planning (MRP) approach, applied in production planning and management has some weaknesses. Despite several shortcomings, the MRP concept is still widely used in practice for materials planning and control. One of the major drawbacks is that MRP does not explicitly take into consideration any uncertainty inherent in the planning data (see Vollmann et al., 2005).

Decision makers usually are more confident making linguistic judgments than crisp value judgments. This phenomenon results from inability to explicitly state their preferences owing to the fuzzy nature of the comparison process. Many studies have continually introduced the fuzzy concept to improve MCDM and solve linguistic and cognitive fuzziness problems. For example, fuzzy theory and AHP are combined to become the Fuzzy AHP (FAHP) method (Cheng, 1997; Cheng et al., 1999), which is a fuzzy extension of AHP, and was developed to solve hierarchical fuzzy problems. FAHPs are systematic approaches to the alternative selection and justification problem that use the concepts of fuzzy set theory and hierarchical structure analysis. FAHP can be applied to measure fuzzy linguistic cognition, and suffers form the disadvantage of unstable (i.e., non-unique) results being obtained by different defuzzification methods, and the ordering of alternatives will arise ranking reversion (Gharakhani،2012).

The remainder of this paper is organized as follows: Section 2 discusses the Effective Factors in MRP implementation. Section 3 discusses the fuzzy AHP method. Section 4 outlines an empirical study to show the process of AHP method to priorities the Effective Factors in MRP implementation. Section 5 carries our conclusions and suggestions.

2. Effective Factors in MRP implementation

Material requirement planning (MRP) is a plan for the production and purchase of the components used in making items in the master production schedule. It shows the quantities needed and when manufacturing intends to make or use them (Arnold، 1998). The application of this popular tool in materials management has greatly reduced inventory levels and improved productivity. Based on the previous literatures, we focus on eight Effective Factors in MRP implementation. The factors used in relevant literatures are as follows:

Top management support, Formal project planning, Data Accuracy, Organizational arrangement, Education, Control policies and procedures, software / hardware Characteristics and employees' individual Characteristics (Alberto petroni, 2002).

3. The fuzzy AHP method

3.1. Analytic hierarchy process (AHP)

The AHP methodology, which was developed by Saaty (1980), is a powerful tool in solving complex decision problems.AHP integrates experts' opinions and evaluation scores, and devises the complex decision-making system into a simple elementary hierarchy system. The evaluation method in terms of ratio scale is then employed to perform relative importance pair-wise comparison among every criterion. This method decomposes complicated problems from higher hierarchies to lower ones. In the AHP approach, the decision problem is structured hierarchically at different levels with each level consisting of a finite number of decision elements. The upper level of the hierarchy represents the overall goal, while the lower level consists of all possible alternatives. One or more intermediate levels embody the decision criteria and sub-criteria (Partovi, 1994).Through AHP, the importance of several attributes is obtained from a process of paired comparison, in which the relevance of the attributes or categories of drivers of intangible assets are matched two-on-two in a hierarchic structure.

3.2. Determining the evaluation dimensions weights

This research employs fuzzy AHP to fuzzify hierarchical analysis by allowing fuzzy numbers for the pairwise comparisons and find the fuzzy preference weights. In this section, we briefly review concepts for fuzzy hierarchical evaluation. Then, the following sections will introduce the computational process about fuzzy AHP in detail.

3.2.1. Establishing fuzzy number

To deal with vagueness of human thought, Zadeh (1965) first introduced the fuzzy set theory, which was oriented to the rationality of uncertainty due to imprecision or vagueness. A major contribution of fuzzy set theory is its capability of representing vague data. The theory also allows mathematical operators and programming to apply to the fuzzy domain. A fuzzy set is a class of objects with a continuum of grades of membership.

The mathematics concept borrowed from Hsieh, Lu, and Tzeng (2004) and Liou et al. (2007).

A fuzzy number Ã on R to be a TFN if its membership function is $\mu_{\tilde{A}}(x)$: R → [0, 1] is equal to following Eq. (1):

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{(x-l)}{(m-l)} & l \le x \le m \\ \frac{(u-x)}{(u-m)} & m \le y \le u \\ 0 & otherwise \end{cases} \quad (1)$$

From Eq. (1), l and u mean the lower and upper bounds of the fuzzy number Ã, and m is the modal value for Ã (as Fig. 1). The TFN can be denoted by Ã= (l, m, u).

3.2.2. Determining the linguistic variables

Generally, the decision-making problem is made under uncertainties, vagueness, fuzziness, risk, time pressure and some information is incomplete or missing. For example, it is difficult for decision makers to give an exact value to express their opinion on a company's capability. They prefer to describe their feeling in the fuzzy term. The triangular fuzzy number is the simplest fuzzy number and is used most frequently for expressing linguistic terms in research (Chen, 2000; Deng, 2006).

An appropriate linguistic variable set can help decision makers to give right judgments on decisions.

Here, we use this kind of expression to evaluation dimension by nine basic linguistic terms, as ''Perfect,'' ''Absolute,'' ''Very good,'' ''Fairly good,'' ''Good,'' ''Preferable,'' ''Not Bad,'' ''Weak advantage'' and ''Equal'' with respect to a fuzzy nine level scale. In this paper, the computational technique is based on the following fuzzy numbers defined by Gumus (2009) in Table 1. Here, each membership function (scale of fuzzy number) is defined by three parameters of the symmetric triangular fuzzy number, the left point, middle point, and right point of the range over which the function is defined. (Note 1).

3.2.3. Fuzzy AHP

Fuzzy theory has been widely used for assisting in decision making where fuzziness exists in defining variables (Seo et al., 2004).

AHP involves the principles of decomposition, pairwise comparisons, and priority vector generation and synthesis. Though the purpose of AHP is to capture the expert's knowledge, the conventional AHP still cannot reflect the human thinking style. Therefore, fuzzy AHP, a fuzzy extension of AHP, was developed to solve the hierarchical fuzzy problems. In the fuzzy AHP procedure; the pairwise comparisons in the judgment matrix are fuzzy numbers that are modified by the designer's emphasis.

Then, we will briefly introduce that how to carry out the fuzzy AHP in the following sections.

Step1: Construct pairwise comparison matrices among all the elements/criteria in the dimensions of the hierarchy system. Assign linguistic terms to the pairwise comparisons by asking which is the more important of each two dimensions, as following matrix Ã.

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{\alpha}_{12} & \cdots & \tilde{\alpha}_{1n} \\ \tilde{\alpha}_{21} & 1 & \cdots & \tilde{\alpha}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{\alpha}_{n1} & \tilde{\alpha}_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{\alpha}_{12} & \cdots & \tilde{\alpha}_{1n} \\ 1/_{\tilde{\alpha}_{12}} & 1 & \cdots & \tilde{\alpha}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/_{\tilde{\alpha}_{1n}} & 1/_{\tilde{\alpha}_{2n}} & \cdots & 1 \end{bmatrix}$$

Where

$$\tilde{\alpha}_{ij} = \begin{cases} \tilde{9}^{-1}, \tilde{8}^{-1}, \tilde{7}^{-1}, \tilde{6}^{-1}, \tilde{5}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{1}^{-1}, \tilde{8}^{-1}, \tilde{1}, \tilde{2}, \tilde{3}, \tilde{4}, \tilde{5}, \tilde{6}, \tilde{7}, \tilde{8}, \tilde{9}, & 1, i \ne j \\ 1 & i = j \end{cases}$$

Step 2: To use geometric mean technique to define the fuzzy geometric mean and fuzzy weights of each criterion by Hsieh et al. (2004)

$$\tilde{r}_i = \left(\tilde{\alpha}_{i1} \otimes \ldots \otimes \tilde{\alpha}_{ij} \otimes \ldots \otimes \tilde{\alpha}_{in}\right)^{1/n}$$

$$\widetilde{w}_i = \tilde{r}_i \otimes [\tilde{r}_1 \oplus \ldots \otimes \tilde{r}_i \oplus \ldots \oplus \tilde{r}_n]^{-1}$$

Where $\tilde{\alpha}_{ij}$ is fuzzy comparison value of dimension i to criterion j, thus, $\tilde{r}_i$ is a geometric mean of fuzzy comparison value of criterion i to each criterion, $\widetilde{w}_i$ is the fuzzy weight of the ith criterion, can be indicated by a TFN, $\widetilde{w}_i =$

(lw_i, mw_i, uw_i). The lw_i, mw_i and uw_i stand for the lower, middle, and upper values of the fuzzy weight of the ith dimension.

4. Data analysis

Data analysis is divided into three sub-sections: (1) Fuzzy AHP questionnaire design, (2) The calculation process of fuzzy AHP method, (3) analyzing the evaluation criteria of significance.

4.1. Fuzzy AHP questionnaire design

This research designed questionnaire for fuzzy AHP. This questionnaire composed of two parts; the first part outlines each criteria definition for easy understanding and response. The second part is a pairwise comparison to evaluate the importance of each criterion using Scale of fuzzy number that displayed in table 1.

4.2. The calculation process of fuzzy AHP method

This study uses an expert interview method. The objects were professional experts of the Iran khodro Company in Iran (15 experts). The evaluation factors symbols in this study are as follows: Top management support (A), Formal project planning (B), Data Accuracy (C), Organizational arrangement (D), Education (E), Control policies and procedures (F), software / hardware Characteristics (G) and employees' individual Characteristics (H).

Data collected from the experts was analyzed with the fuzzy AHP method. The steps were conducted as the following.

We adopt fuzzy AHP method to evaluate the weights of different dimensions for the Effective Factors in MRP implementation. Following the construction of fuzzy AHP model, it is extremely important that experts fill the judgment matrix. The following section demonstrates the computational procedure of the weights of factors.

(1) According to the committee with fifteen representatives about the relative important of factor, then the pairwise comparison matrices of factors will be obtained. We apply the fuzzy numbers defined in Table 1. We transfer the linguistic scales to the corresponding fuzzy numbers.

(2) Computing the elements of synthetic pairwise comparison matrix by using the geometric mean method suggested by Buckley (1985) that is:

$\tilde{\alpha}_{ij} = \left(\tilde{\alpha}_{ij}^{1} \otimes \tilde{\alpha}_{ij}^{2} \otimes \ldots \otimes \tilde{\alpha}_{ij}^{12}\right)$, for $\tilde{\alpha}_{12}$ as the example:

$\tilde{a}_{12}$ = (1/6,1/7,1/8)⊗ (1/3,1/4,1/5) ⊗ ⋯ ⊗ (1/2,1/3,1/4)$^{1/15}$ =$(1/6 \times 1/3 \times \cdots \times 1/2)^{1/15}$, $(1/7 \times 1/4 \times \cdots \times 1/3)^{1/15}$, $(1/8 \times 1/5 \times \cdots \times 1/4)^{1/15}$
= (0.680,0.591,0.534)

It can be obtained the other matrix elements by the same computational procedure, therefore, the synthetic pairwise comparison matrices of the nine representatives will be constructed as follows:

	A	B	C	D	E	F	G	H
A	1	(0.680,0.591, 0.534)	(1.258,1.350, 1.419)	(3.543,4.699, 5.773)	(2.632,3.369, 4.181)	(4.047,5.316, 6.193)	(3.007,3.896, 4.714)	(0.625,0.462, 0.289)
B	(1.469,1.692, 1.873)	1	(1.239,1.140, 1.079)	(2.971,3.856, 4.712)	(0.714,0.556, 0.409)	(1.176,2.103, 2.984)	(1.003,1.053, 1.218)	(5.413,6.389, 7.143)
C	(0.803,0.748, 0.714)	(0.807,0.911, 0.937)	1	(5.487,6.242, 7.121)	(0.269,0.217, 0.152)	(1.905,2.863, 3.614)	(0.723,0.539, 0.381)	(1.922,2.783, 3.568)
D	(0.282,0.211, 0.167)	(0.336,0.261, 0.214)	(0.182,0.158, 0.141)	1	(3.420,4.286, 5.121)	(0.834,0.691, 0.476)	(1.148,0.861, 0.612)	(3.274,4.161, 5.081)
E	(0.368,0.287, 0.226)	(1.402,1.798, 2.444)	(3.717,4.608, 6.578)	(0.292,0.228, 0.192)	1	(1.259,1.592, 2.127)	(4.685,5.514, 6.704)	(0.980,1.115, 1.362)
F	(0.245,0.182, 0.161)	(0.850,0.475, 0.335)	(0.525,0.349, 0.276)	(1.187,1.443, 2.101)	(0.794,0.628, 0.470)	1	(1.333,1.813, 2.341)	(1.239,1.674, 2.114)
G	(0.329,0.243, 0.210)	(0.997,0.949, 0.821)	(1.383,1.855, 2.624)	(0.871,1.159, 1.631)	(0.213,0.180, 0.147)	(0.747,0.523, 0.364)	1	(0.514,0.394, 0.342)
H	(1.621,2.158, 3.452)	(0.184,0.156, 0.139)	(0.520,0.359, 0.281)	(0.305,0.239, 0.194)	(1.020,0.897, 0.732)	(0.807,0.597, 0.473)	(1.923,2.532, 2.912)	1

(3) To calculate the fuzzy weights of factors, the computational procedures are displayed as following parts

$$\tilde{r}_1 = \left(\tilde{\alpha}_{11} \otimes \tilde{\alpha}_{12} \otimes \tilde{\alpha}_{13} \otimes \ldots \otimes \tilde{\alpha}_{1,12}\right)^{1/8}$$

$$= \left((1 \times 0.680 \times \cdots \times 0.625)^{1/8}, (1 \times 0.591 \times \cdots \times 0.462)^{1/8},\ (1 \times 0.534 \times \cdots \times 0.289)^{1/8}\right)$$
= (1.669, 1.821, 1.877)

Similarly, we can obtain the remaining $\tilde{r}_i$, there are:
$\tilde{r}_2 = (1.493, 1.663, 1.780)$
$\tilde{r}_3 = (1.123, 1.157, 1.172)$
$\tilde{r}_4 = (0.809, 0.742, 0.664)$
$\tilde{r}_5 = (1.158, 1.232, 1.385)$
$\tilde{r}_6 = (0.801, 0.732, 0.645)$
$\tilde{r}_7 = (0.651, 0.606, 0.583)$
$\tilde{r}_8 = (0.723, 0.667, 0.634)$

For the weight of each factor, they can be done as follows:

$$\tilde{w}_1 = \tilde{r}_1 \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \oplus \tilde{r}_4 \oplus \tilde{r}_5 \oplus \tilde{r}_6 \oplus \tilde{r}_7 \oplus \tilde{r}_8)^{-1}$$
$$= (1.669, 1.821, 1.877) \otimes (1/(1.877 + \cdots + 0.634)\ , 1/(1.821 + \cdots + 0.667), 1/(1.669 + \cdots + 0.723))$$
= (0.190, 0.211, 0.223)

We also can calculate the remaining $\tilde{w}_i$, there are:

$\tilde{w}_2 = (0.170, 0.193, 0.212)$
$\tilde{w}_3 = (0.128, 0.134, 0.139)$
$\tilde{w}_4 = (0.092, 0.086, 0.079)$
$\tilde{w}_5 = (0.132, 0.149, 0.165)$
$\tilde{w}_6 = (0.091, 0.085, 0.076)$
$\tilde{w}_7 = (0.074, 0.070, 0.069)$
$\tilde{w}_8 = (0.082, 0.077, 0.075)$

(4). to apply the COA method to compute the BNP value of the fuzzy weights of each factor: To take the BNP value of the weight of A1 (Inadequate selection) as an example, the calculation process is as follows

$$BNP_{w1} = \frac{[(U_{w1} - L_{w1}) + (M_{w1} - L_{w1})]}{3 + L_{w1}}$$

$$= \frac{[(0.223 - 0.190) + (0.211 - 0.190)]}{3 + 0.190} = 0.208$$

Then, the weights for the remaining factors can be found as shown in Table 2. Table 2 shows the relative weight of eight Effective Factors in MRP implementation, which obtained by FAHP method.

4.3. Analyzing the evaluation factors of significance

This study integrates fifteen questionnaires from expert interviews to find out the evaluation factors of significant, and then calculates the Weights of factors as shown in Table 2.The weights for each factor are: Top management support (0. 208), Formal project planning (0. 191), Data Accuracy (0. 133), Organizational arrangement (0. 086), Education (0. 149), Control policies and procedures (0. 084), software / hardware Characteristics (0. 071), and employees' individual Characteristics (0. 078) . From the fuzzy AHP results, we can understand the most important Effective Factors in MRP implementation are Top management support (0. 208) and Formal project planning (0. 191).Moreover, the less important factor is software / hardware Characteristics (0. 071).

Table 1. Membership functions of linguistic scale (example)

Fuzzy number	**Linguistic**	**Scale of fuzzy number**
9	Perfect	(8, 9, 10)
8	Absolute	(7, 8,9)
7	Very good	(6, 7,8)
6	Fairly good	(5, 6,7)
5	Good	(4, 5,6)
4	Preferable	(3, 4,5)
3	Not bad	(2, 3,4)
2	Weak advantage	(1, 2,3)
1	Equal	(1, 1,1)

Table 2. The weights and rank of factors**.**

Dimensions	Weights	BNP	Rank
(A) Top management support	(0.190, 0.211, 0.223)	0.208	1
(B) Formal project planning	(0.170, 0.193, 0.212)	0.191	2
(C) Data Accuracy	(0.128, 0.134, 0.139)	0.133	4
(D) Organizational arrangement	(0.092, 0.086, 0.079)	0.086	5
(E) Education	(0.132, 0.149, 0.165)	0.149	3
(F) Control policies and procedures	(0.091, 0.085, 0.076)	0.084	6
(G) software / hardware Characteristics	(0.074, 0.070, 0.069)	0.071	8
(H) employees' individual Characteristics	(0.082, 0.077, 0.075)	0.078	7

5. Conclusion

MRP is a commonly accepted approach for replenishment planning in major companies. The MRP-based software tools are accepted readily. Most industrial decision makers are familiar with their use. The practical aspect of MRP lies in the fact that this is based on comprehensible rules, and provides cognitive support, as well as a powerful information system for decision making (Gharakhani, 2011).The purpose of this study is Identifying and Prioritization Effective Factors in MRP implementation Using FAHP Approach. The survey results show that the most important Effective Factors in MRP implementation are Top management support and Formal project planning.Moreover, the less important factor is software / hardware Characteristics. If Iran Khodro Company will implement Material requirements planning system the best way, it should much attention focused on the Top management support, Formal project planning and Education.

In this paper, one major limitation is the evaluation effort required with this technique. In a decision-making process, the use of linguistic variables in decision problems is highly beneficial when performance values cannot be expressed by means of crisp values. The next limitation of this study it can be noted that this research has been done only in Iran Khodro Company and its results can not be fully extended to all companiesLack of necessary resources and time constraints of this project are another limitation.In this paper, we present AHP as a generalized method to ranking risk factors under a fuzzy environment. Future study can identify and ranking Effective Factors in MRP implementation by different methods such as ELECTRE, TOPSIS and VIKOUR. Further research can survey direct and indirect effects of each factor through dematel method. Researchers can identify and rank factors in implementing material requirements planning systems in other manufacturing companies.

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