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Applying The Fuzzy Analytic Network Process Approach For The Selection Of Suppliers/ A Case Study In Ur General Company

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Abstract:

The research aims to use one of the multi-criteria decision tools, which is the entrance to the fuzzy network analysis, to select the suppliers that the company should choose to provide it with the raw materials it needs to carry out its production activities related to the production of midwives. The research was based on a number of main criteria, which are six criteria (quality, cost, reliability, delivery, ethics and financial position) and binary comparisons were extracted to determine the importance of these criteria. A computer program based on the Matlab language was designed to apply the entrance and get the importance of the sub-criteria and take the opinions of eight experts in the company to get the results.

The researcher reached a set of results, the most important of which is the need to choose the suppliers by focusing on the quality standard and the reliability standard, as it is the most important in choosing them to provide the company with the materials it needs to enter into the manufacture of the product that enables it to compete with other companies operating in the same industrial sector.

Keywords: supplier selection, multi-criteria decision, fuzzy Analytic network analysis

Introduction:

The organization needs to use many tools, means and accurate scientific methods in making some of the multiple decisions, including the process of selecting the best suppliers who can be relied upon in providing the needs of materials for the purpose of continuing production operations and the success of the work of the supply chain and achieving success in the competitive environment of the company, so the process of evaluation and selection of suppliers is considered It is an important and frequently repeated process in industrial companies due to the large number of purchases, the need for raw materials and repeated demand. This makes dealing with suppliers and the selection process a repetitive process, which made the need to facilitate and take the appropriate method to conduct this process an urgent necessity by relying on accurate and clear scientific methods and approaches away from personal assessments. In the sixties of the last century, interest in issues of ambiguity and uncertainty emerged, and production management is one of those fields rich in using fuzzy logic methods and tools, especially in the fields of advanced manufacturing systems. The term fuzzy logic goes back to its roots in the theory of fuzzy sums, and perhaps the reason for the emergence of this logic lies in the problems arising from dealing with cases of uncertainty and inaccuracy of data so that traditional approaches are no longer effective in finding the best solutions to these problems, and on this basis, the

theory of fuzzy sums was developed As an effective algebraic mathematical method in light of a vague environment shrouded in high uncertainty, as despite the human efficiency in predicting the course of things at the level of description, but he lacks this efficiency in prediction in quantitative terms, which prompted the use of fuzzy relationships in this field, the fuzzy models Linguistics allow the possibility of translating verbal phrases into numerical phrases and thus quantitatively dealing with any situation of uncertainty. This confirms the importance of applying the theory of fuzzy aggregates in various fields, including in the field of selecting suppliers. One of the important methods used in selecting suppliers is the fuzzy network analysis method. The resulting ambiguous ANP enhances the potential of the ANP to deal with inaccurate and uncertain human comparison judgments. It allows multiple representations of uncertain human preferences, as clear, separator and ambiguous judgments and can find resolution from incomplete sets of binary comparisons. An important feature of the proposed method is that it measures the asymmetry of uncertain human preferences through an appropriate consistency index. At the same time, process capability indicators are presented to demonstrate and verify the feasibility and effectiveness of proposed methods in the future. The proposal can provide the best method for selecting suppliers, which reduces the cost to the company, facilitates the purchase case, and enables the company to achieve a competitive advantage.

Theoretical Side:

1- The concept of supplier selection

It is the process of finding the right suppliers who can provide the organization with the right quality products or services at the right price, in the right quantities, and at the right time (Dargi etal.2014:692). These supplying companies are keen to improve and develop their own goods and services in order to be selected by the purchasing companies, and they are always working to meet the buyers' needs. Equipped companies face a problem when they do not have the necessary knowledge of what is expected of them, so they find it difficult to develop their companies, goods, capabilities and knowledge (Holm & Vo, 2015: 1-2). The selection of suppliers is a decision process with the aim of reducing the initial pool of potential suppliers to the final choices. Decisions are based on the evaluation of suppliers based on different quantitative and qualitative criteria. The selection of suppliers may require searching for new suppliers or selecting suppliers from the existing pool of suppliers (Galankashi etal., 2015: 690). There are many roles that suppliers take on: manufacturing parts and components, assuring and insuring product quality in order to indirectly help manage the increased costs of their downstream partners. The capacity, cost or quality of suppliers of manufactured parts or components can significantly affect the overall performance of the entire supply chain (Sinio, 2017:13).

The process of selecting suppliers is a strategic decision that includes risks and uncertainty due to its strategic importance and requires the participation of decision makers from the marketing and finance departments, as well as from the production management. One of the main goals of manufacturing companies is to achieve zero defect in production, so it is important to reduce the existing supply chain problems in order to achieve this goal (Gurung & Phipon, 2017: 72)).

2- Criteria for selecting the supplier:

The companies that make the purchase depend on a set of criteria that differ from the standards adopted by other companies, even those operating within the same industry sector, due to the different characteristics of the companies, their production goals and many other justifications (Ho et al., 2008:405). The criteria for selecting suppliers also change over time, and are also affected by environmental changes represented by technological, economic and political changes (Singh, 2012:35 & Sagar). The criteria that are critical in evaluating suppliers depend on the type of good or service and the purchase cases, which are either the purchase of new materials for the first time, modified or repeated purchases. The information required by each case varies. In the case of buying a new material from a new supplier, it is fraught with

great risk and requires an evaluation of all the approved standards. In the case of repeated purchase from a known supplier, the uncertainty is low and the evaluation is lower for the standards (Imeri, 2013: 64)) (Jokinen, 2009:3). Lummas & Vokurka, 1999) explained that these standards differ to some extent for suppliers of strategic commodities from non-critical commodities, and he divided these criteria into three categories: product quality factors, performance factors and general factors (Jokinen, 2009:32). Recently, these standards have become increasingly complex. The realization that a well-selected group of suppliers can make a strategic difference in a company's ability to provide continuous improvement in customer satisfaction is prompting the search for new and better ways to evaluate and select suppliers. The use of multiple suppliers also provides greater flexibility due to the diversity of the overall organization's requirements and enhances competitiveness among alternative suppliers.. Nowadays, it is important to structure the problem and explicitly evaluate relevant criteria before arriving at the final decision. It also divides the choice of supplier into quantitative and qualitative attributes. The selection of appropriate criteria also depends on the purchase status (Taherdoost etal,2019,1028)). And the most used criteria that were used in the research (quality, cost / delivery / reliability, ethics and financial position of the supplier).

3- The entrance to the fuzzy network analysis FANP

A- Multi-criteria decision

There are many cases where decisions are desirable and satisfactory to their makers which are examined and analyzed on the basis of several criteria. For example when choosing a transportation company one takes into consideration criteria such as monthly income, workplace and marital status. When planning production one takes into account objectives such as increasing income, reducing costs, reducing waste, and increasing employee satisfaction. Only one considers the criterion such as profit, cost, efficiency, time, etc. in the models such as linear planning, integer planning, non-linear planning, assignment and most of the classical models of operational research. On the other hand, in multi-criteria decision-making models, several criteria are used simultaneously to determine the best option. In the past two decades, multi-parameter decision-making models have been given special attention by researchers in the field of decision-making. These techniques can formulate the problems related to decision-making in the form of a decision-making matrix and perform the necessary analyzes on it (Najafi & Naji, 2014:18). Multi Criteria Decision Making (MCDM) is a structured framework for analyzing decision problems characterized by multiple and conflicting objectives. Multi-criteria decision-making techniques are well suited to dealing with management and planning problems and have also been used in environmental management, energy policy analysis, farm management, food security, forest management, natural area protection, water management, soil management and wildlife management, wetland management and National Parks Administration. The decision to choose an MCDM method must wait until the analyst and decision-makers understand the problem, possible alternatives, different outcomes, discrepancy between criteria, and the level of uncertainty in the data. Dag ˘deviren et al, 2010: 8144)).

B - Fuzzy sets

This theory was accepted in the 1960s and 1970s and was introduced by the scientist Lotfi Zadeh, writing: “The concept of the fuzzy set provides a convenient starting point for constructing a conceptual framework that in many respects parallels the framework used in the case of normal sets, but is more general than the latter. It has a much wider scope of application, particularly in the areas of pattern classification and information processing." Essentially, this framework provides a natural way of dealing with problems where the source of inaccuracy is the lack of well-defined criteria for class membership rather than the presence of random variables (Zimmermann, 2010: 318). Decision makers can easily assign different weights to different criteria for the supplier selection problem (Yücel & Güneri, 2008: 470).

Zadeh proposed the theory of fuzzy groups and introduced the concept of membership function. Fuzzy set theory deals with problems of real-world linguistic variables. The fuzzy trigonometric number appears as a triple (l, m, r) (Chang etal., 2011: 1853) as in Figure (1)

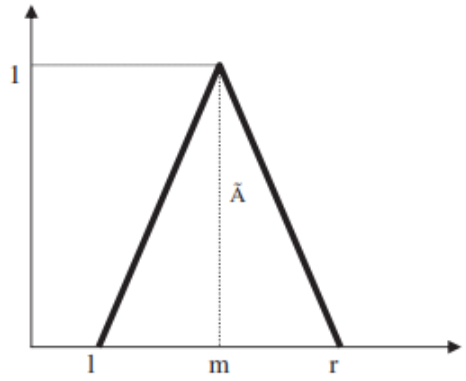


Figure (1) Fuzzy Triangular Numbers

The membership function is defined as

$$\mu_{\tilde{A}}(y) = \begin{cases} 0, & y < a \\ y - a/b - a, & a \leqslant y \leqslant b \\ c - y/c - b, & b \leqslant y \leqslant c \\ 0, & y > c \end{cases}$$

And the list of binary comparisons that were adopted to study the relationships between the main and secondary criteria, depending on the fuzzy linguistic variables of the trigonometric function presented by the watchmaker, shown in Table (1)

Table (1) Trigonometric variables

No.	The name of the linguistic variable in English	Its value
1	abs important	(9,9,9)
2	Very important	(6,7,8)
3	Important	(4,5,6)
4	Weak	(2,3,4)
5	Equal	(1,1,1)

c- Fuzzy network analysis

It is one of the multi-criteria decision-making methods introduced by the watchmaker in 1996 (Yilmaz etal., 2011:257). It is a comprehensive decision-making technique that captures the results of dependence and feedback within and between groups of items. The Analytical Hierarchy Process (AHP) serves as the starting point for the ANP. The Analytical Network Process (ANP) is a more general form of AHP, as it includes feedback and interrelationships between decision attributes and alternatives. ANP is a coupling of two parts, where the first part consists of a control hierarchy or a network of criteria and sub-criteria that control interactions, while the second part is a network of influences between items and groups (Pal etal., 2013: 2671)

The fuzzy mesh analysis process includes the following steps:

1- Determining the main and sub-criteria.

2- Determining the relationships between the main criteria (external relations) and subsidiary criteria (internal relations).

3- Doing binary comparisons by experts.

4- Calculation of the consistency constant for the expert matrix.

5- Extracting prioteries for standards at the expert level.

6- super matrix extraction.

Application side:

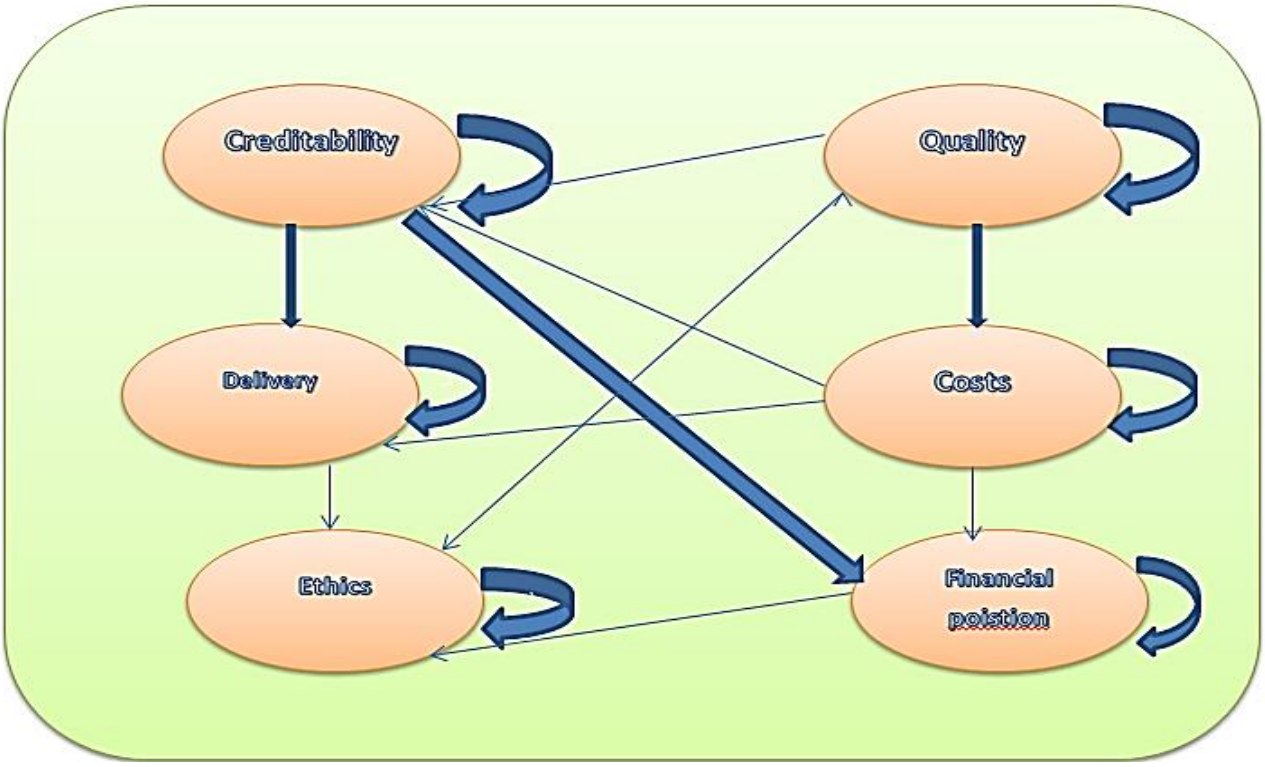
The network analysis approach was applied in Ur Company for the manufacture of midwives according to the previously mentioned steps, which are 1: Choosing the main and secondary criteria as shown in Table (2).

main criterion	Its symbol	No.	secondary criterion	symbol	criterion type

quality	Q	1	Conformance of specifications to specified standards	Q1	qualitative
		2	Compliance of materials with special conditions	Q2	qualitative
		3	Reliability	Q3	qualitative
		4	The supplier obtained the ISO certificate	Q4	qualitative
Costs	C	1	Purchasing price	C1	quantitative
		2	Discounts	C2	quantitative
		3	Distribution cost (transportation(	C3	quantitative
Delivery	D	1	On time delivery	D1	qualitative
		2	Delivery Flexibility	D2	qualitative
		3	waiting period	D3	quantitative
creditability	R	1	Company History	R1	qualitative
		2	supplying sources	R2	qualitative
		3	financial stability	R3	qualitative
		4	The certificate obtained by the supplier	R4	qualitative
Financial Position	FP	1	Disclosure of financial records	FP1	qualitative
		2	Financial stability and credit strength	FP2	qualitative
Ethics	E	1	Supplier Legal Compliance	E1	qualitative
		2	information disclosure	E2	qualitative
		3	Ease of dealing	E3	qualitative
		4	occupational health and safety systems	E4	qualitative

2/ Presenting the internal and external relationships between the main and sub-standards

The relationships between the standards were identified by the company's experts and shown in Figure (2).



3: pairwise comparisons were made for experts, and the weights and importance of the main and subsidiary criteria were obtained, as shown in Table (3).

Table (3) Elementary Super matrix

	Super Matrix Notation																				
	Goal	Q1	Q2	Q3	Q4	R1	R2	R3	R4	C1	C2	C3	D1	D2	D3	E1	E2	E3	E4	FP1	FP2
Goal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q1	0	0.95178	0.39341	0.15512	0.65904	0	0	0	0	0.1586	0.08563	0.24262	0	0	0	0	0	0	0	0	0
Q2	0	0.02584	0.28951	0.24794	0.13714	0	0	0	0	0.63247	0.8509	0.40989	0	0	0	0	0	0	0	0	0
Q3	0	0.01773	0.26639	0.56693	0.17418	0	0	0	0	0.16096	0.04944	0.33355	0	0	0	0	0	0	0	0	0
Q4	0	0.00465	0.05069	0.03001	0.02964	0	0	0	0	0.04797	0.01403	0.01394	0	0	0	0	0	0	0	0	0
R1	0	0	0	0	0	0.78002	0.34944	0.42223	0.69328	0	0	0	0.66889	0.34488	0.32634	0	0	0	0	0.60434	0.53834
R2	0	0	0	0	0	0.18658	0.42102	0.3001	0.14537	0	0	0	0.06277	0.48522	0.48917	0	0	0	0	0.1647	0.14339
R3	0	0	0	0	0	0.02745	0.1606	0.20006	0.04287	0	0	0	0.22044	0.14917	0.14102	0	0	0	0	0.20722	0.28284
R4	0	0	0	0	0	0.00595	0.06894	0.07762	0.11848	0	0	0	0.0479	0.02073	0.04346	0	0	0	0	0.02374	0.03542
C1	0	0	0	0	0	0	0	0	0	0.02399	0.1628	0.41756	0	0	0	0	0	0	0	0	0
C2	0	0	0	0	0	0	0	0	0	0.92001	0.808	0.3229	0	0	0	0	0	0	0	0	0
C3	0	0	0	0	0	0	0	0	0	0.056	0.0292	0.25954	0	0	0	0	0	0	0	0	0
D1	0	0	0	0	0	0	0	0	0	0	0	0	0.9014	0.81582	0.93509	0	0	0	0	0	0
D2	0	0	0	0	0	0	0	0	0	0	0	0	0.04888	0.06644	0.03853	0	0	0	0	0	0
D3	0	0	0	0	0	0	0	0	0	0	0	0	0.04973	0.11773	0.02638	0	0	0	0	0	0
E1	0	0	0	0	0.7669	0	0	0	0	0	0	0	0	0	0	0.82535	0.51038	0.48662	0.24969	0	0
E2	0	0	0	0	0.08198	0	0	0	0	0	0	0	0	0	0	0.12535	0.1255	0.3027	0.10334	0	0
E3	0	0	0	0	0.01307	0	0	0	0	0	0	0	0	0	0	0.03182	0.0155	0.0559	0.03398	0	0
E4	0	0	0	0	0.13806	0	0	0	0	0	0	0	0	0	0	0.01748	0.34862	0.15478	0.61299	0	0
FP1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4572	0
FP2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5428	0
Q	0	0.53107	0.60903	0.6071	0.66638	0.69575	0.65266	0.6321	0.69994	0.59501	0.54956	0.59131	0.60849	0.66889	0.64348	0.51306	0.49711	0.65945	0.66739	0.56315	0.71718
R	0	0.0188	0.04613	0.06637	0.04728	0.12381	0.09234	0.05354	0.08972	0.09822	0.11494	0.10531	0.08112	0.09204	0.10806	0.07446	0.10378	0.08436	0.07363	0.07051	0.05907
C	0	0.0137	0.02431	0.01681	0.02631	0.02515	0.02229	0.02123	0.03225	0.02333	0.0174	0.02583	0.01829	0.01814	0.03165	0.02654	0.0414	0.02162	0.02334	0.03298	0.02088
D	0	0.04787	0.03851	0.03482	0.04957	0.02206	0.02427	0.02661	0.02419	0.03431	0.03759	0.02648	0.02626	0.02256	0.02587	0.03242	0.04567	0.02085	0.02387	0.05018	0.02453
E	0	0.26115	0.17537	0.16724	0.12624	0.07643	0.1048	0.14262	0.09277	0.12711	0.14117	0.14742	0.13691	0.11355	0.11175	0.1603	0.15775	0.12045	0.12383	0.17666	0.10062
FP	0	0.12741	0.10665	0.10765	0.08422	0.0568	0.10364	0.1239	0.06113	0.12201	0.13934	0.10364	0.12893	0.08481	0.0792	0.19321	0.15429	0.09327	0.08794	0.10651	0.07772

4: The super matrix was extracted as shown in Table (4).

Table (4) Super Matrix

		Q1	Q2	Q3	Q4	R1	R2	R3	R4	C1	C2	C3	D1	D2	D3	E1	E2	E3	E4	FP1	FP2	
Q	0.00	0.53	0.59	0.60	0.59	0.69	0.66	0.65	0.69	0.58	0.57	0.58	0.64	0.66	0.65	0.52	0.53	0.60	0.63	0.49	0.00	1.00
R	0.00	0.02	0.04	0.06	0.05	0.12	0.10	0.08	0.10	0.07	0.08	0.07	0.09	0.10	0.10	0.08	0.09	0.08	0.08	0.07	0.00	0.00
C	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.00	0.00
D	0.00	0.05	0.04	0.04	0.04	0.02	0.02	0.03	0.02	0.04	0.04	0.04	0.02	0.02	0.02	0.03	0.04	0.03	0.03	0.03	0.00	0.00
E	0.00	0.26	0.20	0.18	0.17	0.08	0.10	0.12	0.09	0.17	0.17	0.17	0.11	0.11	0.11	0.16	0.15	0.14	0.13	0.11	0.00	0.00
FP	0.00	0.13	0.11	0.11	0.13	0.06	0.09	0.10	0.07	0.12	0.13	0.11	0.10	0.09	0.09	0.19	0.15	0.13	0.11	0.07	0.00	0.00

Conclusions:

The main most important criterion is the quality criterion, where its sub-criteria obtained the highest weights, and this means that the company puts the specifications of the materials that are agreed upon with the supplier in the first place in order to be able to produce its products according to international specifications and standards, and that the most important sub-criteria for quality is reliability, that is The raw materials that the company deals with in the production of its product are midwives, and this indicates that the company is keen to provide its products with high quality, as quality is a necessity for the success of the company's work, and then the suppliers' application of specifications comes according to the special conditions desired by the company, and these conditions came to implement the customer's desire In the specifications that must be available in the midwife product, as the company works and produces according to demand, the quality of the manufacturing processes as well as the quality of the products offered to the customer and the impact on customer satisfaction.

The ethics criterion came in second place in terms of importance, as the company should deal with suppliers who have transparent behavior in dealing, revealing and giving all the information that shows the company's position on the law and the ease of dealing with it and concluding contracts with it. The company may work to form partnerships with this supplier in the future.

As for the third criterion, it was the reliability criterion for the supplier, which is represented by the company's long history and the sources of supply. Sometimes the supplier is a second party that the company deals with, such as contracting companies. And the criterion of the cost incurred by the company when it is supplied with materials by the supplier in relation to the purchase price, facilities and the discount that he obtains when purchasing in different quantities. Then comes the delivery standard because of its importance in delivering the final product to the customer on time. We believe that these standards are indicators to enable the organization to achieve competitive advantages as it is a local company with a long and deep-rooted history and one of the important companies in the Iraqi industrial sector.

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