Suppliers Benchmarking in Cement Manufacturing system for Ready-made Concrete based on Fuzzy Multi-Objective Linear programming Approach

M.H. Tabrizi[1], Hua-ming Song[2]

[1] Department of Economics, Management, Nanjing University of Science and Technology, Nanjing, 210094, P.R. China. E-mail: m.mirfattah1@outlook.com
[2] Department of Economics, Management, Nanjing University of Science and Technology, Nanjing, 210094, P.R. China. E-mail: huaming@njust.edu.cn

Abstract: As many studies shown that the manufacturing sustainability of supply chain depends on the providence and procurement the materials by suppliers strategically. Most of the recent researches had been focused on the logistics costs, the requirements of quality and quantity in CRM but not given on the selecting the members who has prepared the initial essentials or raw materials for production. Recently, there is a high pressure on supply chain members for minimizing or decreasing the costs for their supply process. As some researchers believe that cooperating and providing the initial and raw materials such as Cement needs more attention and noticing to their production conditions, meanwhile cooperating and providing the essential order from the old suppliers based on having data of their background and past reputation would be guaranteed in standard conditions and quicker while safer than finding new and different suppliers according to their new conditions. In this paper, the authors convey on the integrated approach in order to select the most appropriate and suitable cement suppliers in the supply chain manufacturing systems, regarding to the ready-made concrete production issue, by using the methods of Multi-Objective LP and ANP in the format of Fuzzy. At the beginning, Fuzzy ANP is chosen to be analysed and normalized in order to find the priorities by the weights through the comparison in pairwise the criteria two by two. Meanwhile, the selected criteria are included of cost, low quality in percentage, lead time, the range of demands and cement manufacturing attributes. The weights of these criteria are used in fuzzy Multi-Objective linear programming for selecting the appropriate supplier in benchmarking. Here, in this study the illustrative model is presented with a database from a real position as a case study to demonstrate the outcome and effects of the illustrative model. The illustrative method and offered model can manipulate the real world case studies when there is a dilemma (vagueness) in the problem depends on the inputted data.
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1 Introduction

By respecting and regarding to benchmarking of suppliers which is as a matter of fact and play main role in manufacturing supply chain, there is a close and positive relation between the initial materials (raw materials) for suppliers benchmarking and manufacturing supply chain system implementation. There have been so many studies and researches focused on supplier benchmarking from the varieties of perspectives of supply chain systems sustainability. However, a few studies have addressed the construction manufacturing plants such as cement and the related issues for the supplier evaluation. Recently, some leading companies have already started working to develop the next generation cement manufacturing management as a project and the related issues for supplier benchmarking.

An observed survey conducted by companies showed the high amount of percentages of the total materials in supply chain is generated from direct operational activities of the company and the rest of the materials in percentages (of production) is generated from other indirect activities such as production from raw material and component parts supplier, electricity supplier and single organization (production or manufacturing) from other supply chain members. In this scenario, selecting the suppliers has played a permanent role to minimize the costs and expenses through supply chain processing levels while impacts on the overall purchasing cost (Xia and Wu, 2007). As surveyed in another research work that among the various terms of supply chain, sourcing, inventory and logistics are significant (Chopra, 2007). According to reports, more than fifty percent of the manufacturers claimed that in the future they would cease the business and provide the initial and essential materials with the suppliers, if they don't manage and check their quality before business. Due to increase consciousness about climate changes, companies are imposing pressure on their suppliers to manage their cement initial materials as one of the conditions for doing business with them. Supplier (propensity) to minimize the total costs for producing or manufacturing cement is presented as one of the criteria for supplier benchmarking. Therefore, suppliers should make a whole assessment of their current capabilities in terms of cement manufacturing management and set appropriate targets for the future reduction of the quality for their material. The suppliers who measure and publish their own supplied materials are strategically more preferable than others, caused they contribute the providers to manipulate their initial materials necessities. However, merely a few numbers of supply chain manufacturers could have extensive gained knowledge about the low cost material for producing and procuring on their supply chain and according to objective of supplier benchmarking, choose the highest potential suppliers in order to meet the customers' demands. This study deals with low cost material as supplied for producing and procurement cement for supplier benchmarking. The relevant literature on cement supplier benchmarking is discussed in the following parts.

De Boer et al proposed a model and process for the assessment of supplier's performance that includes four main steps in supplier benchmarking: problem definition, formulation of selection criteria, pre-qualification or preliminary screening and final selection. The cost and manufacturing process were the important considerations for supplier evaluation. The other researchers developed a knowledgeable and flexible system to evaluate the supplier's (material or locations) performance through reviewing the published articles of 2008 to 2012 on decision making techniques and priorities (Cha, 2013). Cost, management competencies, management system, and other relevant attributes to the production were considered as evaluating the criteria in the model of analysing. In another case proposed a model by applying the methods of analytical network process Analytic Network Process (ANP) and fuzzy logic based on the material supplier evaluation (Lu, 2007). Meanwhile, another author, his researches are on constructing an assessment framework of the supplier by using analytical network process Analytic Network Process (ANP) for Taiwanese Electronics Company. Five criteria such as procurement management, R & D management, process management, incoming quality control and management system were analysed in the model. In different work the author has conveyed on the high- tech industry by searching on an integrated model and regarding with six criteria as well (Lee, 2009). The regarding criteria concluded of quality, technology capability, production controlling, environmental management. The other author developed a model of supplier evaluation with regarding to economic environmental, social issues; rough set theory was used to deal with the information (Bai, 2010). As it has been surveyed on the incorporation performance in order to evaluate the suppliers based on "max-min" approach while using two linear programming models to maximize and minimize the supplier's performance to achieve the best measurement in target (Talluri and Narasimhan, 2003). It has been developed a model consists of several supply chain systems with multiple suppliers with the goal of determining an optimal inventory policy by using mixed integrated non-linear programming model that is able to handle the items in transferring among the varieties of supply chain and estimating the amount of suppliers' allocative placing orders (Mendoza and Ventura, 2010). In another article the author has developed a model to evaluate the objective of supplier selection by applying the artificial neural network (ANN) and two multi attribute decision analysis (MADA) methods that consists of data envelopment analysis (DEA) and analytic network process Analytic Network Process (ANP). It's developed a model to classify the solution approaches of a fuzzy multi-criteria for evaluating suppliers' performance by levels of aspiration to attain the objective function then the interpreted model can be applied by using fuzzy operators (Arikan and Gungor, 2007). As proposed fuzzy multi criteria decision framework for Fuzzy aspiration levels for objective functions in order to evaluate the vendors, maximum capacity of the vendors consists of RHS, allocative budget ranges for vendors by using fuzzy programming with determined Werner's fuzzy or operator (Madronero, 2010). Fuzzy analytic network process within the variety of people decision making scheme under in complete preference relations was used in their model. The earlier studies have merely focus on the supplier evaluation issue and mostly on multi-criteria decision making approaches such as ANP, fuzzy ANP, fuzzy ANP, Topsis, rough set theory and other approaches for estimating the suppliers. Such these models are less robusted, caused the quantification of order amount to a particular supplier is impossible. In some recent studies, has been used hybrid model by using fuzzy ANP, and fuzzy linear programming that is proposed for selecting the most appropriate and achievable supplier. The present study is concluded as the following parts. In the second section, explored the literature in relevant to supplier benchmarking methodologically. In third section which is discussed the theory of fuzzy. In forth section, the models of mathematical multi-objective is analysed. In fifth section that represents the real case study, relevant to the gained results and obtained solution with discussing on the results. In sixth section, as the final section of this study, is presented the conclusions and recommendations on the issue and solutions.

2 Supplier evaluation problem

In business activities, the sides by the production and manufacturing processing system is always changing and it should be flexible in any request, quantity and quality and in continuous coordination due to the customer's demands diversification. This phenomenon is not useful for the manufacturing cost system and leads to increase the costs. Despite of it, decision for purchasing the material from a particular supplier is as a chaos for decision making strategy in order to be sure about the coordinating and manufacturing activities for long time and saving to survive the incorporation and firm from spending high amount of expenses as well. However, some of the companies and suppliers also try to increase their competencies and outsourcing process to reduce the operating costs system. Hereby, an optional assessment is essential to choose the right and proper supplier that is flexible for replacing continuously at the time. The distinctions of suppliers in operation technically and skilfully, it leads to make it difficult to make decision for selecting the most suitable and achievable supplier. By the above mentioned terms, in some of recent studies are used mathematical models of programming and planning for making decision. According to Ghodsypour et al. research work and his findings, by presenting a hybrid approach included of ANP and linear programming to solve the supplier selection problem.

As shown through the model of the research paper by the authors, the total cost in logistics in the constraint of budget, quality, service levels, etc. were represented in their model.

In one research work the researcher shows a goal programming model that minimized the total costs while leading to maximize the reliable and qualified delivery for selecting the suppliers and percentages of allocative quota (Wadhwa, 2007).

Ku et al. proposed a fuzzy goal programming approach for selecting the vendors in regarding to the effect of vague and uncertain information in decision making approach (Ku, 2010). Meanwhile, as the same as previous research, the authors applied fuzzy multi objective linear programming for determining the suppliers by lowest costs with the highest quality as the ordered quality (Govindan, 2013). Liao et al. developed a model of mathematical calculation for selecting the suppliers in regarding to the variants for the supply capabilities in suppliers and customers' demands in period of time. At this model, there is the optimization of the revenue as the customers' demand goes up simultaneously (Liao, 2011). However, Gao did researches on purchasing the raw materials for Steel plant in large amount in China, by using some equations of multi-objective linear programming model (Gao, 2003). Meanwhile the other author proposed an integrated fuzzy multi criteria on decision making method and multi-objective programming approach to aim of supplier selection and allocative amount of orders in the area of green supply chain on which firstly used analytical structure of network method to obtain the relative weights for the criteria of quantity and quality then had been used the fuzzy Topsis method in order to evaluate the suppliers who are chosen (Julai Azari Khojasteh, 2011). There are varieties of studies, which have investigated on these mentioned approaches in their methodology for supplier selection. Talluri approved a mixed model of Multi Objective Programming (MOP) and the DEA based on an issue for supplier selection. These authors applied multi-objective programming in order to obtain the quality of products and they used DEA to evaluate and find out the suppliers' competencies (Talluri, 2008).

Furthermore, the authors obtained the solution for an allocative order problem on suppliers by considering the criteria of qualitative scale as well as qualitative conditions (Wua, 2010). As the other author used ANP method to prior the criteria on Agile/ Lean manufacturing system strategically. Despite of it, the authors tried to prove the results by using the goal programming (PGP) and gained the optimal solution and quantity for orders from suppliers (Wu and Barnes, 2011). In another research work the author applied the method of fuzzy extended analytical network processing technique (FEANPT) for selecting all suppliers over the world (Buyukozkan, 2011). Moreover, the author developed a supplier benchmarking model based on ANP and fuzzy linear programming approach (Erol, 2011). The researchers used fuzzy ANP and fuzzy goal for the problem of supplier selection. Through their model, fuzzy ANP has been used in order to obtain the weights of criteria according to scales. Then, the weights by each criterion were used in fuzzy goal programming subsequently (Dubey, 2012). As proposed a supplier selection problem while using fuzzy SWOT (strength, weakness, opportunities and threaten) analysis and fuzzy linear programming in their framework (Amin and Zhang, 2012).

3 Fuzzy Theory Approach

According to the past studies, decision making is hard to for uncertainties and vagueness level of degree and conditions entirely. Although this condition can be solved by using fuzzy theory, which was developed by researchers. In decision making, it is normal such attributes of fuzziness and vagueness condition for problems. As Chen's findings in his researches, the incompleteness and vagueness can be controlled by increasing the model robustness of data (Chen and Lin, 2006). If the uncertainties and fuzziness condition are ignored by decision making process, therefore the obtained results and conclusion of the model may not be effective. Fuzzy theory will be used to solve such a problems. Mehrjerdi proposed developed model found that it can be observed in times that the decision-makers provide an uncertain solution and result rather than a certain and precise value. However, it is very difficult to calculate this qualitative scale (Mehrjerdi, 2012). In fuzzy condition, using the ANP method for comparing the criteria's weight in pairwise would not be appropriate for real decision making in nature as well. During solving the problems, the levels of uncertainty for decision making is permanent term. Using fuzzy theory in cooperating with ANP would be suggested and more appropriate and effective than conventional ANP model. As Bozbura found in his researches that the concept of fuzzy theory issued in fuzzy-ANP models and for selecting the alternatives, the normal ANP method would be applied for obtaining the calculations (Bozbura and Beskese, 2007).

So many other studies have been applied on these subjects such as Yucel worked on fuzzy ANP model for decision making and many researches have conveyed the different methods for obtaining the results from fuzziness and uncertainties area of data collection (Yucel and Guneri, 2011). Furthermore, there are lots of different available methods in order to calculate the fuzzy numbers meanwhile each method has some advantages and disadvantages in progress generally. Zadeh investigated on a ranking method intuitively that calculates the scales of triangular fuzzy numbers according to proposed coronbach's alpha method and centroid method considerable to rank the fuzzy numbers (Zadeh, 1965). The extent analytical method proposed to calculate, caused this method computation in this problem is much easier than other fuzzy ANP approaches and it has been taken less time to obtain the solution (Zadeh, 1976). On the other side, this method can overcome all deficiencies of standard and conventional ANP approach. The fuzzy ANP method not only manipulate the decision-makers', experts' uncertainties, but also it provides the flexibility and robustness for the model. In the fuzzy triangular models the numbers would be calculated the priority of the variable decisions by pairwise comparison. Here, it will explain some general terms of fuzzy theory as follows. These general terms and procedures are used for all types of fuzzy applications usually. The amount of M as shown in figure 1 is fuzzy number in triangular fuzzy. A fuzzy number can be shown by (a, b, c) and its membership function defined as below (Lee and Kang, 2005).

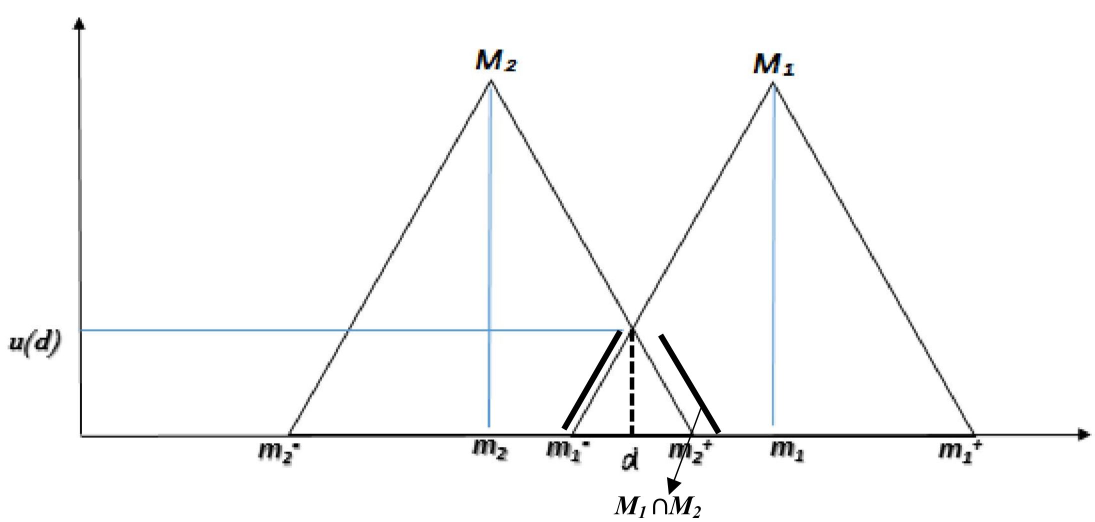

Fig. 1. *Two triangular fuzzy numbers M_1 and M_2 (Lee, 2009).*

Two triangular number M_1 (m_1^-, m_1, m_1^+) and M_2 (m_2^-, m_1, m_2^+) compared with together and compute in the following relations:

When $m_1^- \le m_2^-$, $m_1 \ge m_2$, $m_1^+ \le m_2^+$

The possibility degree would be defined as (1):

$$V(M_1 \geq M_2) = 1 \quad (1)$$

For calculating the highest amount of $\mu(d)$ we can obtain as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu(d) = \frac{m_1^- - m_2^+}{(m_2 - m_2^+) - (m_1 - m_1^-)} \quad (2)$$

The fuzzy extent is calculated as below:

$$F_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1}, i = 1, 2,..., n \quad (3)$$

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} m_{ij}^-, \sum_{j=1}^{m} m_{ij}, \sum_{j=1}^{m} m_{ij}^+\right), j = 1, 2,..., m \quad (4)$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} M_{ij}^+}, \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} M_{ij}}, \frac{1}{\sum_{i=1}^{n}} \sum_{j=1}^{m} M_{ij}^-\right) \quad (5)$$

Where a convex fuzzy number is concluded of;

$$V(F \geq F_1, F_2,..., F_K) = \min V(F \geq F_i), i = 1,2,..., k \quad (6)$$

$$d(F_i) = \min V(F_i \geq F_k) = W_i' \; k = 1,2,..., n \text{ and } k \neq i \quad (7)$$

According to the process, the weights of the criteria will be obtained as follows:

$$w' = (w_1', w_2', ..., w_n')^T \quad (8)$$

The weights of criteria after normalization as below:

$$W = (w_1, w_2, ..., w_n)^T \quad (9)$$

4 Supplier benchmarking Model

The following terms as assumptions of the problem, index set, decision making variables and parameters are regarded to make the equations and relations in order to calculate the multi-objective approach in supplier benchmarking model.

i. From each supplier is purchased just one product.
ii. The quantity discount is not determined just in this model.
iii. Suppliers have no right for any deficiency.
iv. The lead time for suppliers is constant.

Main Index in this model

i= index for suppliers, i= 1,2,3,...,n for all.
j= index for objectives, j= 1,2,3,..,J for all.
K= index for constraints, k= 1,2,3,...,k for all.

Decision making Variables

(X_I) The quantity of order as valued for each supplier i.

Parameters

(D)represents as aggregate demand of each considering item during stable planning duration of time.
(n) represents as the number of competing suppliers for selection.

(P_i)represents as the unit price for each item for each ordered amount of (X_i) to the supplier (i).
(L_I) represents as the amount of lead time units by the supplier (i).
(Q_i) represents as the amount of rejected items which is delivered by the supplier (i).
(G_i) represents as cement manufacturing attribute in system for supplied product by supplier (i).
(U_i) represents as upper limit of the amount which is available for the supplier (i).
(B_i) represents as the allocated value for budget constraint to each supplier (i).
(C^{cap}) represents as the total cost for cement in finding the sources of the material to each supplier (i).

Model

The typical model is made for supplier benchmarking in this problem as follows;

$$\text{Minimize } Z_1 = \sum_{i=1}^{n} P_i X_i \qquad (10)$$

Here, the objective function would minimize the total cost of making order.

$$\text{Minimize } Z_4 = \sum_{i=1}^{n} C_i X_i \qquad (11)$$

Here, the objective function would minimize the rejected products amount due to the quality problem.

$$\text{Minimize } Z_2 = \sum_{i=1}^{n} Q_i X_i \qquad (12)$$

Here, the objective function would minimize the lead time items from the suppliers.

$$\text{Minimize } Z_3 = \sum_{i=1}^{n} L_i X_i \qquad (13)$$

Here, the objective function would minimize the total cement manufacturing costs for procurement and production.

Subject to;

$$\sum_{i=1}^{n} X_i = D \qquad (14)$$

This constraint is represented as the total aggregate demand of the considering item.

$$X_i \le U_I \qquad (15)$$

The constraint ensures the maximum number of available suppliers

$$\sum_{i=1}^{n} C_i X_i \le C^{cap} \qquad (16)$$

The mentioned constraint is shown the restriction on expenses for sourcing

$$P_i X_i \le B_i \qquad (17)$$

The above constraint is represented as the restriction on the budget amount allocate to each supplier for supplying the items.

$X_i \ge 0$ and integer just. (18)

This constraint ensures all variables are greater than zero and integer only. Actually, in the real world for selecting the suppliers, there are many indices or factors, which are unknown and not optional properly, that leads to produce a vagueness and uncertainty in the decision area of data. The mentioned vagueness could not be determined by the defined problem. Therefore, the determined models are not able to solve the local or regional problems. The techniques for fuzzy theory would be applied here to determine and find out the solutions. It is deserved to maximize the quantity of placing order rather than slightly make the satisfying level of constraints higher as Kumar found these advanced results (Kumar and Vrat, 2006). By using a multi-objective fuzzy linear programming tries to control linguistics issues properly in decision making (Zimmermann, 1978). The decision making in fuzzy approach consists of two categories, symmetric and asymmetric fuzzy decision making. The same weights would be considered for constraints and objectives in fuzzy decision making symmetrically, however the weights for constraints and objectives in fuzzy decision making are different in asymmetric conditions. According to the fuzzy goals and fuzzy constraints, the multi-objective programming could be transformed into the crisp linear programming equations (Zimmermann). By regarding to the weighted model increased model which is developed by Tiwari to obtain the procedure for the supplier benchmarking problem as the real world weights are not fixed or the same and all the objective functions and constraints are different (Tiwari and Dharmahr, 1987). In this study, the weights have been calculated by using fuzzy ANP method as the model is proposed here.

4.1 Fuzzy linear Programming

This method, fuzzy linear programming, that is investigated by Zimmermann (1978). This method is concluded of fuzzy goals, and fuzzy constraints that can be flexible and rebuilt it again in a form that is able to solve like a normal type of linear programming problems. As the conventional rules of linear programming problem that is proposed by Zimmermann, here there are some given LP model through the relations (19-21);

Minimize $Z = Cx$ (19)

Subject to;

$Ax \leq b$ (20)

$X \geq 0$ (21)

The fuzzificated form of the above linear programming would be as below; (22 - 24)

$\tilde{C}_x \leq Z$ (22)

$\tilde{A}x \leq b$ (23)

$X \geq 0$ (24)

Through made relations; this symbol ~ < in constraint means "essentially smaller than or equal to". However, the value for $\tilde{A}$ *and* $\check{C}$ represent a fuzzy number.

4.2 Membership (substitute) function

As bellman and Zadeh proposed the fuzzy set. The fuzzy set (A) in (*x*) is defined as below;

$$A = \{ x, \mu_x (x) \mid x \in X \} \quad (25)$$

Where μ_A (x): x → [0, 1] that is called as membership function of (A) and μ_A (x) is the degree for the membership in which *x* belongs to *A.* the fuzzy set (A) is determined by its membership function μ_A (x) and level of function (membership function) which is as a subset of the non-negative real numbers and their value is finitive and usually can find a place through this interval [0,1].

The defined and mentioned linear membership function as used in this model could be considered for all of the fuzzy parameters. As defined, a linear membership function is included of some attributes which their values are steadily risen or decreased over the range of parameters. There lower and upper case in limitation of values in acceptability of the parameters in needs.

As determined the fuzzy objective by $\check{Z} \in X$ that is a fuzzy subset of (x) defined by its membership function μ_A (x): x →[0, 1] and the linear membership function is fuzzy objective are given as:

$$\mu_{zj} = \begin{cases} 1 & \text{if } Z_j(x) \leq Z_j^{min} \\ \left[\dfrac{Z_j^{\max} - Z_j(x)}{Z_j^{\max} - Z_j^{\min}}\right] & \text{if } Z_j^{min} \leq Z_j \leq Z_j^{max} \quad \text{where } j = 1,2,\ldots,J. \\ 0 & \text{if } Z_j(x) \geq Z_j^{max} \end{cases} \quad (26)$$

In this relation, Z_j^{min} is defined as $\mathbf{min_j Z_j (X^*)}$ and $\mathbf{Z_j}^{\mathbf{max}}$ is $\mathbf{max_j\ Z_j (X^*)}$ and X^* is the optimized and optimum solution for the model in the problem. The fuzzy constraint as defined by $\check{C} \in X$, is a fuzzy subset of (x) which is attributed to the membership function μ_c (x): x →[0,1]. As given in below, the linear membership function for the fuzzy constraints is in relation (27);

1 if $g_k(x) \leq b_k$,

$$\mu_{C_k}(x) = \begin{cases} 1 & \text{if } g_k(x) \leq b_k \ , \\ [1 - \dfrac{g_k(x) - b_k}{d_k}] & \text{if } b_k \leq g_k(x) \leq b_k + d_k , \\ 0 & \text{if } b_k + d_k \leq g_k(x) \end{cases} \quad (27)$$

Where the value of $k=1,2,3,...,k$ in all fuzzy parameters. As figured out the tolerance interval by d_k.

4.3 Solution through the optimization and formulation

As determined the fuzzy solution by all the fuzzy sets consist of not only fuzzy objective but also fuzzy constraints (Bellman & Zadeh) and the membership fuzzy functions for the fuzzy solution would be represented by the relation (28);

$$\mu_s(x) = \mu_s(x) \cap \mu_c(x) = \min [\mu_z(x); \mu_c(x)] \quad (28)$$

In the above equation μ_z (x), μ_c (x) and μ_s (x), all are the membership functions of the objectives, constraints and solutions significantly. Herein, the solution for the supplier benchmarking is fuzzy model for the J fuzzy multiple objectives and the K constraints maybe represented as relation (29);

$$\mu_s(x) = \left(\bigcap_{j=1}^{J} \mu_z(x) \right) \cap \left(\bigcap_{k=1}^{K} \mu_c(x) \right) \quad (29)$$

$$= \min [_{j=1,2,...,J} \min \mu_{z_j}(x), _{k=1,2,...,K} \min \mu_{c_k}(x)]$$

The maximum level of the membership value is the response for the problem or the optimum solution of the supplier benchmarking problems as shown in relation (30);

$$\mu_s(x^*) = \max \mu_s(x) = \max \min [_{j=1,2,...,J} \min \mu_{z_j}(x), _{k=1,2,...,K} \min \mu_{c_k}(x)] \quad (30)$$

$x \in S$

4.4 Crisp optimization of the supplier benchmarking model

The programming model of fuzzy that is concluded of J types of objectives and (k) types of constraints, all are transformed to the new formulation that is called crisp optimization for the fuzzy programming model. As considered crisp optimization, can be observed by two relations and equations as follows (31)-(35);

$\lambda (Z_j^{max} - Z_j^{min}) + Z_j (x) \leq Zj^{max} j= 1, 2, 3,..., J$ for all (j). (31)

$\lambda (d_x) + g_k (x) \leq b_k + d_k k = 1, 2, 3,..., K$ for all (K). (32)

$Ax \leq b$ for all defined constant, (33)

$x \geq 0$ and integer value (34)

$0 \leq \lambda \leq 1$ (35)

As referred to the Zimmermann's findings in 1978, the optimal lower and upper case of area, Z_j^{min} and Z_j^{max}, would be obtained and calculated by solving the same objective function in times as calculated the minimization and maximization form respectfully. Z_j^{min} which is the lower case of the optimum values, would be obtained by supplier benchmarking problem like a linear programming problem (36)-(39)

Minimizing the objective function as ***min*** $\boldsymbol{Z_j (x)}$, $j = 1,2,3,..,J$ for all (j) (36)

s.t.;

$g_k (x) \leq b_k + d_k k = 1, 2, 3,..., K$ for all (k) (37)

$Ax \leq b$ for all defined constant, (38)

$x \geq 0$ and integer value. (39)

Z_j^{max} is the upper case of the optimal values is gained by finding the result as a supplier benchmarking problem similarly as a LP problem (40)-(43)

Minimizing the objective function as ***min*** $\boldsymbol{Z_j (x)}$, $j = 1,2,3,..,J$ for all (j) (40)

S.t.;

$g_k (x) \leq b_k + d_k k = 1, 2, 3,..., K$ for all (k) (41)

$Ax \leq b$ for all defined constant, (42)

$x \geq 0$ and integer value. (43)

With accordance to Zimmermann's obtained findings, the objective functions and constraints weights are as the same as the crisp equations and formulation for the supplier benchmarking problems. Although the supplier benchmarking problem, in the real world and naturally, the weights for the objective functions are not the same. By applying the same weights, all the value and amount of important objective function would be decreased.

Consequently, in result, an optimum solution for supplier benchmarking problem might not be gained in that case. For preventing to this problem in reality, it would be adopting and applying the obtained additive data in new model. The new model, by the adoptive weighted that is used in multi-objective optimization problems. By multi membership function of fuzzy goals in linear weighted utility function according to corresponding weights and the updated findings would be obtained the results.

The new model by the weights that is proposed by Tiwari [33] is as follows;

$$\mu_D(\text{x}) = \sum_{j=1}^{J} w_j \mu_{z_j}(\text{x}) + \sum_{k=1}^{K} \beta_K \mu_{g_k}(\text{x}) \quad (44)$$

$$\sum_{j=1}^{J} W_j + \sum_{k=1}^{K} \beta_K = 1 \quad , W_j, \square_k \geq 0 \quad (45)$$

In above relations, β_k is the weights coefficient that shows the permanent relation between the fuzzy goal and other fuzzy constraints. Here, there are the crisp single objective programming that is equivalent to the above relations.

$$\text{Max} \sum_{j=1}^{J} W_j \lambda_j + \sum_{k=1}^{K} \beta_k \gamma_k \quad (46)$$

s.t.;

$$\lambda_j \leq \mu_{z_j}(\text{x}), \quad j = 1, 2, ..., J \quad (47)$$

$$\gamma_k \leq \mu_{g_k}(\text{x}), \quad k = 1, 2, ..., K \quad (48)$$

$$g_p(x) \leq b_p, \; p = 1, 2, ..., M \quad (49)$$

$$\lambda_j, \gamma_k \in [0, 1], \; j = 1, 2, ..., J \text{ and } k = 1, 2, ..., K \quad (50)$$

$$\sum_{j=1}^{J} W_j + \sum_{k=1}^{K} \beta_k = 1 \quad (51)$$

$$X_i \geq 0, \; i = 1, 2, ..., n \quad (52)$$

4.5 Supplier benchmarking based on fuzzy LP

As presented in following part, the mathematical model is illustrated as below, the authors are regarding cost, percentage of low quality, lead time in percentages, manufactured product and demand for cement are in fuzzy format. After making the numbers in format of fuzzy, there are the following relations (53) – (61);

$$\sum_{i=1}^{n} P_i X_i \leq \check{Z}_1 \quad (53)$$

$$\sum_{i=1}^{n} Q_i X_i \leq \check{Z}_2 \quad (54)$$

$$\sum_{i=1}^{n} L_i X_i \leq \check{Z}_3 \quad (55)$$

$$\sum_{i=1}^{n} G_i X_i \leq \check{Z}_4 \quad (56)$$

$$\sum_{i=1}^{n} X_i \cong D \quad (57)$$

$$\square_i \leq U_i \quad (58)$$

$$\sum_{i=1}^{n} G_i X_i \leq CM_{f\&t}^{cap} \quad (59)$$

$$P_i X_i \leq B_i \quad (60)$$

$$X_i \geq 0 \text{ and integer value} \quad (61)$$

4.6 The obtained result and computational procedure

Through this study, there is a combined approach of fuzzy-ANP and fuzzy multi-objective linear programming to use in order to determine the relative weights for criteria in supplier benchmarking. The multiplied weights with each membership function of fuzzy linear programming to present the crisp membership function. In calculations, by using the approach of fuzzy-ANP, it can be obtained the relative weights in each membership function of fuzzy goal in different strategic occasions.

The obtained solutions in order to solve the problem are as following stages of process.

In the first stage, the criteria in supplier benchmarking is identified. In the second stage, the pair-wise comparison of criteria in questionnaire is developed. The questionnaire is concluded of nine-scale in relating to supply chain and operational management. The consisting and inconsistency of the compared results would be checked firstly. The inconsistent result by any decision maker must be filled again. More and more solved the questionnaire until achieving the consistency rate in response. In the third stage, the fuzzy weight of the criteria is estimated by the experts' response. Ď which is determined as a triangular fuzzy number, obtained by combining the experts' idea and opinion (Lee), herein there is a fuzzy triangular number of Ď = (h^-, h, h^+)

Where

$$h^- = \left(\prod_{t=1}^{S} l_t\right)^{1/s}, \quad \forall t = 1, 2, \ldots, S.$$

$$h = \left(\prod_{t=1}^{S} m_t\right)^{1/s}, \quad \forall t = 1, 2, \ldots, S.$$

$$h^+ = \left(\prod_{t=1}^{S} u_t\right)^{1/s}, \quad \forall t = 1, 2, \ldots, S.$$

and (l_t, m_t, u_t) is the weights (priority vectors) for indices is obtained by applying the analysis method by change based on relations, the weights of the indices are gained. In the fifth stage, the objective functions for selecting supplier are calculated. The mentioned objective functions for selecting supplier are calculated. The mentioned objective functions consist of cost minimization, minimization of low quality, minimizations of lead time in delivery to customers and the quality in manufacturing the product. In the sixth stage, the objective function would be chosen and solved. The solved objective function, will be obtained the lower case in the optimum value through solving. In the seventh stage, as previous objective, the other objectives will be continued in solving. The lower case and upper case in any given objective would be calculated based on the same constraints. In the eight stage, the crisp equation by using the weighted additional model represented by Tiwari. The criteria weights that obtained before by the extent analytical manufacturing would be applied to gain the crisp equation. In the ninth stage, the crisp equation in optimization of the fuzzy problem would be done and gained the results.

5 Case Study

The considered case study based on the current model is the manufacturing plant of the cement. The manufacturing plant is fulfills the internal and external placed orders quantity. Most of the foreign customers prefer to provide the II tip of cement for construction. To achieve the demand of the customers, the board or committee has decided to apply the varieties of the criteria into their evaluation process for selecting the suppliers. The decision-makers and experts found it that the suitable and loyal relationship of the supplier manufacturer and suppliers are as a matter of fact and the suppliers are able to share their information to the manufactures regarding to the costs of their manufactured cement. Decision-makers consist of managers in variety districts. The managers of variety districts of purchasing, production line, marketing, QC, R & D. The most proper and appropriate supplier in selection would be the goal of this board or committee. By making final decision on four criteria included of costs, low quality, percentage of lead time and cement manufacturing for supplier benchmarking. When decision-makers have chosen the main criteria for evaluation, the four potential suppliers for preparation of the materials would be selected as source. Then, in a free brainstorming to discuss and negotiate for the managers of the operating systems and purchasing part to find the priority in criteria for using approach of fuzzy analytical network (FANP). In Chart 1, some information are presented about the numbers for membership function of fuzzy and the pairwise comparison among the criteria as shown in that chart.

Chart 1:

Fuzzy Pairwise comparison among the criteria

	Cost	Quality	Lead time	CM f &t shortage [1]	Demand
Cost	(1, 1, 1)	(1, 1.63, 2.62)	(1, 1.64, 2.76)	(1, 1.36, 3.39)	(1, 1.75, 3.82)
Quality	(0.38, 0.6, 1)	(1, 1, 1)	(1, 1, 5)	(1, 1.16, 3.31)	(1, 1, 3)
Lead time	(0.36, 0.6, 1)	(0.2, 1, 1)	(1, 1, 1)	(1, 1, 4)	(0.2, 1, 1)
CM facility & Technology shortage	(0.29, 0.73, 1)	(0.3, 0.625, 1)	(0.25, 1, 1)	(1, 1, 1)	(1, 1.63, 3.36)
Demand	(0.26, 0.57, 1)	(0.33, 1, 1)	(1, 1, 5)	(0.29, 0.61, 1)	(1, 1, 1)

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j} = (1, 1, 1) + ... + (0.29, 0.61, 1) + (1, 1, 1) = (15.86, 22.905, 51.26)$$

$$[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}]^{-1} = (0.0195, 0.0436, 0.0630)$$

Cost: $\sum_{j=1}^{m} M_{g_1}^{j} = (1, 1, 1) + ... + (1, 1.75, 3.82) = (5, 7.38, 13.59)$

Quality: $\sum_{j=1}^{m} M_{g_2}^{j} = (4.38, 4.76, 13.31)$

Lead time: $\sum_{j=1}^{m} M_{g_3}^{j} = (2.76, 4.6, 8)$

CM [1]: $\sum_{j=1}^{m} M_{g_4}^{j} = (2.84, 4.985, 7.36)$

Demand: $\sum_{j=1}^{m} M_{g_5}^{j} = (0.88, 1.18, 9)$

$$F_{Cost} = F_1 = \sum_{j=1}^{m} M_{g_1}^{j} \times [\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}]^{-1} = (0.1, 0.321, 0.86)$$

$$F_{Quality} = F_2 = \sum_{j=1}^{m} M_{g_2}^{j} \times [\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}]^{-1} = (0.0854, 0.207, 0.84)$$

$$F_{Ld.t} = F_3 = \sum_{j=1}^{m} M_{g_3}^{j} \times [\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}]^{-1} = (0.053, 0.2, 0.504)$$

$$F_{C.M} = F_4 = \sum_{j=1}^{m} M_{g_4}^{j} \times [\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}]^{-1} = (0.055, 0.217, 0.463)$$

$$F_{Demand} = F_5 = \sum_{j=1}^{m} M_{g_5}^{j} \times [\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}]^{-1} = (0.017, 0.051, 0.567)$$

$V(F_1 \geq F_2) = 1$; $V(F_1 \geq F_3) = 1$; $V(F_1 \geq F_4) = 1$;
$V(F_1 \geq F_5) = 1$; $V(F_2 \geq F_1) = 0.866$; $V(F_2 \geq F_3) = 1$;
$V(F_2 \geq F_4) = 1$; $V(F_2 \geq F_5) = 1$; $V(F_3 \geq F_1) = 0.769$;
$V(F_3 \geq F_2) = 0.983$; $V(F_3 \geq F_4) = 1$; $V(F_3 \geq F_5) = 1$;
$V(F_4 \geq F_1) = 0.777$; $V(F_4 \geq F_2) = 0.987$; $V(F_4 \geq F_3) = 0.963$;
$V(F_4 \geq F_5) = 1$; $V(F_5 \geq F_1) = 0.633$; $V(F_5 \geq F_2) = 0.7553$;
$V(F_5 \geq F_3) = 0.812$; $V(F_5 \geq F_4) = 0.755$
$d(F_{cost} = F_1) = \text{Min } V(F_1 \geq F_2, F_3, F_4, F_5) = \text{Min }(1, 1, 1, 1) = 1$
$d(F_{Quality} = F_2) = \text{Min } V(F_2 \geq F_1, F_3, F_4, F_5) = \text{Min }(0.866, 1, 1, 1) = 0.866$
$d(F_{ld.t} = F_3) = \text{Min } V(F_3 \geq F_1, F_2, F_4, F_5) = \text{Min }(0.769, 0.983, 1, 1) = 0.769$
$d(F_{C.M} = F_4) = \text{Min } V(F_4 \geq F_1, F_2, F_3, F_5) = \text{Min }(0.777, 0.987, 0.963, 1) = 0.777$
$d(F_{Demand} = F_5) = \text{Min } V(F_5 \geq F_1, F_2, F_3, F_4) = \text{Min }(0.633, 0.7553, 0.812, 0.755) = 0.633$
$W' = (d(F_{Cost}), d(F_{Quality}), d(F_{Ld.t}), d(F_{C.M}), d(F_{Demand}))^T = (1, 0.866, 0.769, 0.777, 0.633)^T =$
$= (0.247, 0.214, 0.190, 0.192, 0.156)$

5.1 Supplier benchmarking based on FLP (Fuzzy Linear Programming)

Here, it is considered just four suppliers for supplier benchmarking problem. The indices or factors for purchasing criteria are concluded of cost, low quality in percentage, lead time and manufacturing attributes for this product that regarded in this model. The constraints of capacity, budget and total purchasing manufactured cement are considered in this model. The above constraints are allocated in natural life. The demand for this product is also known as a fuzzy variable. According to the reports by demand amount, it is estimated approximately twenty thousand and it can vary between 20 – 22thousand. The value of cement capacity would be involved about thirty thousand at this model. The quantity of data for supplier benchmarking is presented in Chart (3). The arithmetical and computational cases for multi-objective LP are as follows. The minimization objective function of (Z_1) that minimizing the total cost for purchasing district of the material. The minimization objective function of Z_2 that minimizes the low level of quality amount according to the problem of quality in product. The minimization objective function of Z_3 that minimizes the lead time for delivery in times. The minimization objective function of Z_4 that minimizes the total shortage for facility and technology of the purchased item.

1) Min Z_{Cost}: 8*X1+5*X2+4*X3+6*X4,
2) Min $Z_{Quality}$: 0.07*x1+0.05*x2+0.02*x3+0.04*x4,
3) Min $Z_{Ld.t}$: 0.08*x1+0.04*x2+0.03*x3+0.02*x4,
4) Min $Z_{CM.facility\ \&\ Technology\ shortage}$: 1.2*x1+1.6*x2+1.3*x3+1.5*x4,

Subject to;
x1+x2+x3+x4 = 22000;

$x1 \leq 4000$
$x2 \leq 12500$
$x3 \leq 8000$
$x4 \leq 5000$
$1.2*x1+1.6*x2+1.3*x3+1.5*x5 \leq 32000$
$3*x1 \leq 12000$
$5*x2 \leq 50000$
$8*x3 \leq 70000$
$6*x4 \leq 15000$
$x1,x2,x3,x4 \geq 0$ and integer

As mentioned before about the numerical model and the gained result, Z_1 that is objective function by set of constraints applied in order to obtain the lower case of solution and later for obtaining the upper case of objective by maximizing the objective function.

Chart (2)

The evaluation amount for the suppliers

Suppliers	P_i($)	Q_i(%)	Ld.t_i(%)	Facility & Technology shortage	U_i	B_i($)
1	8	0.07	0.08	1.2	4000	32000
2	5	0.05	0.04	1.6	12500	50000
3	4	0.02	0.03	1.3	8000	70000
4	6	0.04	0.02	1.5	5000	15000

Chart (3)

The relevant objective function for supplier benchmarking

Number	$(O.F.)^3$	μ=1	μ=0
1	Z_1	109000	126440
2	Z_2	865	977.85
3	Z_3	810	1125.9
4	Z_4	30950	32807

By having the property and data to each of the objective function it would be obtained the upper case and lower case for the other objective function based on the criteria of cost, low level of quality, lead time and facility & technology shortage are shown in Chart (4). As the equations form of crisp for the problem of supplier benchmarking is applied the additional weights in model developed by Tiwari et al., (46) - (52). The obtained weights based on fuzzy-ANP that applied for the crisp equation would be used for supplier benchmarking. The amount and scales for the functions of membership in relating to the objectives, and the constraints would be maximized where in crisp equations, the initial four are as the functions of membership for the objective functions of Z_1, Z_2, Z_3 and Z_4 and even though there is another term for membership function such as (γ_1), as the fifth term for the constraints demand. Here, there are the solutions based on hybrid approach where there is a crisp equation for the problem of study, supplier benchmarking;

Maximize

$(0.257)\ \lambda_1 + (0.214)\ \lambda_2 + (0.190)\ \lambda_3 + (0.192)\ \lambda_4 + (0.156)\ \gamma_1$

Subject to;

$$\lambda_1 \leq \frac{126440 - (8X1+5X2+4X3+6X4)}{17440}$$

$$\lambda_2 \leq \frac{977.85 - (0.07x1+0.05x2+0.02x3+0.04x4)}{112.85}$$

$$\lambda_3 \leq \frac{1125.9 - (0.08x1+0.04x2+0.03x3+0.02x4)}{315.9}$$

$$\lambda_4 \leq \frac{32807 - (1.2x1+1.6x2+1.3x3+1.5x4)}{1857}$$

$\gamma_1 \leq \frac{22000 - (x1+x2+x3+x4)}{100}$

$\gamma_1 \leq \frac{(x1+x2+x3+x4) - 20000}{100}$

1.2*x1+1.6*x2+1.3*x3+1.5*x4 ≤ 32000;
x1 ≤ 4000;
x2 ≤ 12500;
x3 ≤ 8000;
x4 ≤ 5000;
3*x1 ≤ 12000
5*x2 ≤ 50000
8*x3 ≤ 70000
6*x4 ≤ 15000
x1,x2,x3,x4≥0 and integer

By using software Lingo (Version 14) we can solve the model and find the result and solution for this problem of supplier benchmarking. The optimal solution for this model and problem through the equations can be obtained as follows. The amount of λ, as objective term, is equal to 0.293 and the amount of $\lambda_1,\lambda_2, \lambda_3\ \lambda_4, \gamma_1$ in arrangement with 0.37765, 0.144307, 0.506342, 0.44086, 1 and the value for x_1, x_2, x_3, x_4 in arranging are equal to 1500, 10000, 5730, 2500.

Then, the value for the goal functions in problem are equal to Z_1 = 119.920, Z_2= 994.6, Z_3= 941.9,

Z_4= 31999. As Zimmermann had researches on the same problem of the supplier benchmarking with regarding to all the weights for membership function as the same as each other. Therefore, two procedures for solving the problems are possible; either varying the weights for membership function or the same weights for membership function. In this model, as considered an overall equality membership function for all the objective functions of Z_1,Z_2, Z_3, Z_4, that is (λ). Here, it would be considered an overall objective function for the problem and solved the problem again (λ), by regarding the maximization of (λ).

The second solution and method refers to solve the problem of just one and overall value of (λ).

Maximize λ

Subject to;

$\lambda \leq \frac{126440 - (8X1+5X2+4X3+6X4)}{17440}$

$\lambda \leq \frac{977.85 - (0.07x1+0.05x2+0.02x3+0.04x4)}{112{,}85}$

$\lambda \leq \frac{1125.9 - (0.08x1+0.04x2+0.03x3+0.02x4)}{315.9}$

$\lambda \leq \frac{32807 - (1.2x1+1.6x2+1.3x3+1.5x4)}{1857}$

$\lambda \leq \frac{22000 - (x1+x2+x3+x4)}{100}$

$\lambda \leq \frac{(x1+x2+x3+x4) - 20000}{100}$

1.2*x1+1.6*x2+1.3*x3+1.5*x5 ≤ 32000;
x1 ≤ 4000;
x2 ≤ 12500;
x3 ≤ 8000;
x4 ≤ 5000;
3*x1 ≤ 32000
5*x2 ≤ 50000
8*x3 ≤ 70000
6*x4 ≤ 15000
x1,x2,x3,x4 ≥0 and integer

The value for λ is obtained as 0.43 with considering the amounts for x_1, x_2, x_3 and x_4 in arranging are 4000, 10000, 5499, 2500. Z_1 = 118996, Z_2= 989.98, Z_3= 934.97, Z_4 = 31698.7.

As the following chart shows, the solutions of the supplier benchmarking in problem with the higher scaling for demand would be between twenty thousand to twenty two thousand, as having the properties of the optimization in costs, level of quality is obtained about unit, lead time criterion and manufacturing attributes for producing cements, in arrangement with 119.920 dollar in costs, 994.6 units, 941.9 units for the amount of lead time and 31999 kilogram for manufactured cements amount.

Chart (4)

The result of the four objective functions based on Hybrid and Zimmermann methods

Number of Suppliers	Obj. Function	Hybrid (varying in weights)	equal weights in membership Function
1	Z_1	119.920	118996
2	Z_2	994.6	989.98
3	Z_3	941.9	934.97
4	Z_4	31999	31698.7

And as the above chart expressed with considering the equality in the weights, the value for the optimized cost is estimated as 119.920 dollar and the level of quality is about 994.6 units, 941.9 units for the lead time and the amount of manufactured cement is about 31999 *kg* significantly. According to these obtained result for the chosen criteria and selected suppliers among all of the variety criteria and suppliers in scaling, the rank for the first chosen supplier would be 7.6 percent based on Hybrid method, Although the allocative scale for the first supplier based on Zimmermann method is about 18.2 and in percentage that belongs total low quality of purchased items. So this supplier has lost his chance for benchmarking based on decision-makers' opinion. However, the decision-makers as expressed in chart (5) that the allocative scaling to suppliers would be obtained according to the two different ways of solving the problem. The given scale for the suppliers in two different methods are not equal and in each procedure of solving differs, respectively. As in the following chart shown, the most significant effects and the highest percentages of scaling is belonged to the second supplier that in Hybrid approach would be 50.6 % and in Zimmermann approach would be about 45.4 % respectfully. Then the third supplier could be considered as the second rank among the four suppliers and the last supplier is the first supplier that would be considered by the decision-makers as well.

Chart (5)
The allocative scaling for the suppliers

Supplier	U_i	membership function (Varying in weights)	Scale (in %)	membership function (Equality in weights)	Scale (in %)
1	4000	1500	6.8 %	4000	18.2 %
2	12500	10000	45.6 %	10000	45.4 %
3	8000	8000	36 %	5499	24.9 %
4	5000	2500	11.36 %	2500	11.4 %

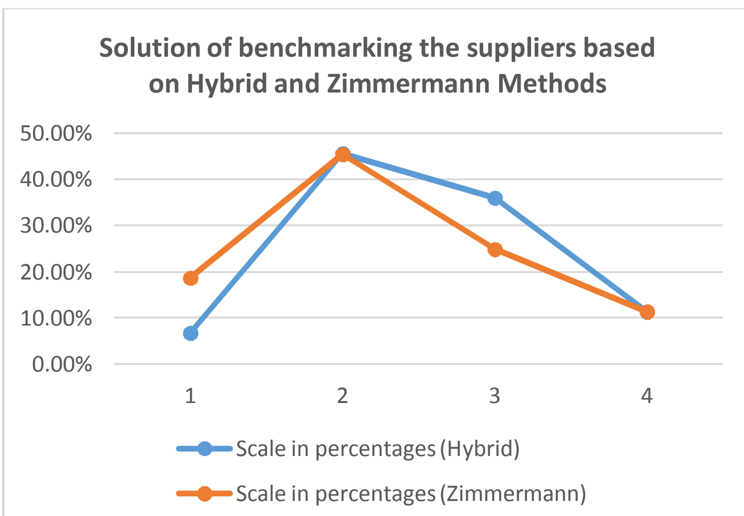

***Fig.2** – Solution of benchmarking the suppliers based on Hybrid and Zimmermann Methods.*

Despite of the comparisons among the suppliers on the chosen criteria such as costs, quality, capacity of products for each suppliers of the cement, lead time, and manufacturing attributes for selecting the appropriate supplier regarding to the same weights for all criteria. Zimmermann considered for the variety of the weights for each of the criteria. The second supplier with 45.4 percent is the best in choosing by using different weights for the variables as the solved model of the hybrid approach and using the similar weights according to Zimmermann approach. The estimated value for hybrid method is about 45.6

percent. Therefore the second supplier can be ordered the higher amount of order because of larger capacity for the product. As considered, the amount of orders are based on the lowest percentages of quality level and least lead time even the lowest costs for logistics and amount of wastes in manufacturing system and having the proper and best property for the cement production (manufacturing) attributes as well. The weight as shown through the chart has lowest amount for supplier the first and the percentage for supplier the forth is estimated and obtained approximately 11.36 percent with despite of the lowest cost among the other suppliers in hybrid method. The rest of suppliers, supplier the second, as the obtained percentage is approximately 45.6 % and that is the highest estimation by this model by considering the lower range of the quality and the highest amount of capacity for the products. In result, the second supplier is estimated in priority of the suppliers in lowest cost, at least quality level of the product and least of lead time but no have adequate capacity in order to supply the product. The differentiates in reaching to the cost goal of the objective function (λ_1), the quality evaluation goal which is shown by λ_2 and λ_3 is represented as lead time goal and λ_4 is represented as cement manufacturing attributes and the general accessed goal is shown by λ. The demand accessibility to the goal which is shown by (γ_1) by regarding to the general achieved goal (λ). The evaluated percentages to the different suppliers based on their different value of (λ). According to these findings, when there is a change in the fuzzy goals as problem variables differs, the changes would be happened in supplier's value of percentages as well. However, while λ is changed, the amount for the fourth supplier didn't change. There is no change for the fourth supplier while the value of λ rose. At this range, the fourth supplier's scale in percentage slightly minimized to 11.4, and the range of percentages of λ changed for the fourth supplier from 11.4% and there will be happened another increasing in the amount of λ from 0.43 to 0.293. Meanwhile by changing the value of λ, the amount for the second and third will be changed. When the value for λ is about 0.293, the second supplier's amount of percentage is about 10000 and for the third supplier's amount of percentage reaches to 8000. In considering to the approach in this study, the value for λ_3 as lead time weight of criteria is estimated as 0.506342. As the decision maker's decisions by resolving the problem and changing the amounts, here λ_1, λ_2 is greater than 0.5 and λ_3 is greater than 0.4 and λ_1 is equal to 1. By solving the problem based on the given data, the amount of general λ is about 0.43, and the achieving goals are λ_1 that is about 0.37765 and the value for λ_2 is 0.144307; and λ_3 is 0.506342and λ_4 is 0.440860 when γ_1 is just one. The amount of variables in solution would be estimated as; x_1, x_2, x_3, x_4, with arrange in 4000, 10000, 5499 and 2500 according to Zimmermann method. Also the optimum solution in objective function of cost is about 118996 dollar and the quality level in total amount is about 989.98 and the amount of lead time is about 934.97 while cement manufacturing attributes in capacity is about 31698.7 *kg*.

Conclusions

By solving this problem in the real world, the process of benchmarking the supplier would be more difficult. The other attributes have influenced in the decisions by the decision-makers such as customer relationship and the customer services fulfill to prepare their demands and the more profits and achievements would be permanent on making decision. So, it would be permanent in order to save and keep the incorporations for the lead time as a matter of fact strategically. As considered through the models, two combined approaches are used, included of fuzzy-ANP and fuzzy multi-objective linear programming. In the fuzzy multi objective linear programming model, cement manufacturing attribute is used as a constraint while benchmarking the supplier for normalization of the weights of the criteria, fuzzy-ANP applied and the fuzzy LP (linear programming) used to find the optional solution for the problem without exact numerical data and vagueness, in this model can be controlled sustainability. This solving method and model is very useful for solving the problems in the real world, practically. As mentioned and proved in the paper, by solving the problem based on considering the same weights for criteria toward finding the optimized solution for the objective functions, there is no similar weights for criteria in the real world strategically. In real problem, the weights for the criteria in objective function are changeable as required by the managers in the supply chain management. The priority of the criteria according to their pairwise comparison obtained through fuzzy-ANP method. The proposed model and method is a permanent tool for the decision making in order to overcome some challenges and debates in problems. Regarding to the case study, cement manufacturing plant, all the process and advancements could be demonstrated in different decision makings area and using fuzzy ANP and fuzzy multi-objective linear programming as tools in order to obtain the optimized solution for a real problem in real case study. The results from LP show that the integrated approach yields significant solving in terms of logistics and overall supply chain costs.

Corresponding Author:

M.H. Tabrizi
Department of Economics, Management, Nanjing University of Science and Technology, Nanjing, 210094, PR China.
Telephone:+86-15040309652
E-mail: m.mirfattah1@outlook.com

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