The Supplier evaluation problem: the state of the art

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Abstract
In today’s competitive world, one of important factor in survival is the reduction of production cost. In the current age the companies for remaining competitive and achieving the customer satisfaction has been paid more attention to supply chain management, so that competition between companies is no longer the case, also there is between supply chains. In this regard, the supplier selection as a strategic key plays an important role in the success of companies. Selecting the right suppliers can significantly reduce the cost of purchasing and Increase the competitiveness of the organization. Decision making and supplier selection is basically a multi-criteria issue. Nevertheless, some of these criteria might be in conflict with each other. This is one of strategic importance to most organizations. The nature of such decisions is usually complex and not structured. The present paper provides a comprehensive literature review on some of articles published for supplier evaluation in recent years.

Keywords: Supplier evaluation, Multi-Criteria Decision Making (MCDM), Literature review, Fuzzy Inference Systems (FIS)

1 Introduction

Early in the last century companies try to increase the market share by focus on the number of manufactured products. After several decades they have attempted to attract customers by delivery of qualified product as soon as possible. In other words, companies were succeeded that offered diverse products at reasonable prices, high quality and in the shortest possible time (Kraljic, 1983).

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But in recent decades, the industries pioneer introducing meet the needs of their customers as achieving a higher share of market. Nowadays, companies are able to maintain their survival that they can adapted to customer needs. A plurality of manufacturing companies, providing a variety of services, promotion marketing and such factors has caused customers’ needs change shape day to day. In today’s competitive world, most enterprises are to reduce their costs and meet customers’ needs while increasing quality of their products. In some kinds of industries, up to 70 percent of costs are associated with purchases process (Ghobadian et al., 1993). Furthermore, the research conducted by Weber et al. (1991) shows that in some hi-tech productions, costs covering raw materials may be more than 80 percent of the total cost. One of the most influential issues in this regard that can highly affect this kind of cost is appropriate approach for supplier selection. The optimal performance of a company in any of the environmental, social and economic factors is directly in relationship with supplied raw materials from suppliers. However, selecting suppliers are not restricted to just cost criterion; other criteria such as quality, risk, on-time delivery and so forth should be involved in the selection process. Therefore, supplier selection is a multi-criteria decision making (MCDM) problem including tangible and intangible criteria. Nevertheless, some of these criteria might be in conflict with each other.

As mentioned above, suppliers, as a key component for profitability and success of organization, play a significant role; Right selection of supplier has a direct effect on profitability by reduction in costs, increasing profit margins, improvement in component quality and timely delivery of products to the end customers (Chan and Kumar, 2007). Sawik (2010) mentions that the goal of supplier evaluation is to ascertain the optimized supplier that can present the best products or services to the customer and become a segment of the organization’s supply chain. Supplier selection and evaluation is a strategic problem with the long-term relationship trend to select suppliers that has just emerged (Araz et al., 2007). Dickson (1966) is one the pioneers in the field of supplier selection. He investigated 23 criteria such as delivery, quality, performance history, warranty, price, technical capability and financial position for selecting appropriate suppliers. Popular criteria of supplier selection are exploited in a review by Ho et al. (2010), including quality, delivery, price/ cost, manufacturing capability, relationship and risk. Impressive supplier and strategies selection can straightly influence supply chain performance, which results in organizational productivity and profitability (Sawik, (2010), Sawik, (2011)).

From a practical point of view, supply chains have some commitments among which are environmental issues (Dekker et al., 2012). Therefore, suppliers cannot be selected regardless of environmental causes such as remanufacturing cases (Xiong et al., 2013) and hazardous materials (Hsu & Hu, 2009). Involving environmental criteria into the supplier selection problem defines Green Supply Chain Problem. This problem not only considers inside practices but also makes commitments to outside sustainability (Ageron et al., 2012) which provides more business opportunities to take advantageous of. In addition, some new legislation put pressure on firms to involve some green management criteria into their decisions (Jabbour et al., 2013). Supplier selection according to environmental criteria can be catch the attention of many researchers. A wide variety of common and green criteria have been considered in supplier selection. These criteria are important and justifiable in the related literature.

Wolf and Seuring (2010) have taken environmental matters into account as a part of supplier selection and service providers. Büyüközkan and Çifçi (2011) studied supplier selection according to corporative social and environmental responsibilities an in their later study. They applied Fuzzy Dematel, fuzzy ANP and Fuzzy TOPSIS to their proposed problem. Yeh and Chuang (2011) developed a model for green partners through mathematical planning and incorporating ISO 14000 considerations into their criteria. In addition to ISO 14000, Tseng and Chiu (2013) defined green purchasing and cleaner production as distinguishable environmental criteria in their integrative model. Emission of greenhouse gases was considered as a major criterion for supplier selection by Shaw et al. (2012). Kannan et al. (2014b) presented a new approach for supplier evaluation and selection in green supply chain management. They implemented their proposed method in an electrical company in Brazil with 12 suppliers to determine the efficiency of the approach.
2 Supplier evaluation techniques

To precise examine the research on supplier evaluation, the rest of this paper classified into thirteen categories; mathematical programming techniques; the fuzzy AHP technique; the Fuzzy TOPSIS technique; the LINMAP technique; the DEMATEL technique; the VIKOR technique; the ELECTRE technique; the Neural Network (NN) technique; the ANP technique; Green and Sustainable Supply Chain Management (GSSCM); Multi-Criteria Group Decision Making (MCGDM); the MULTIMOORA Technique; Nominal Group Technique (NGT). Then we have reviewed some of distinguished paper that published at different journals according to using these techniques. At the end of paper some tables are presented that describe the reviewed paper briefly.

2.1. Mathematical programming techniques

In 2013 a multi-objective model was proposed by Esfandiari and Seifbarghy. The model, in spite of maximizing the gained overall rating from the supplier evaluation process, minimizes purchasing cost, rejected units, and late delivered units. The authors assume that the buyer gets several products from a number of predetermined suppliers. In terms of each product type, the buyer experiences a random demand with a probability distribution of Poisson. These authors also assume that the buyer must set a minimal order quantity for every supplier. The main implication of this study is that the price that each supplier was offered relied linearly to the size of each product. The goals include: minimizing the purchasing cost from suppliers, rejected items, maximizing the total scores got from evaluation of the suppliers, and late delivered items. Researchers of the paper employ the L-1 metric method for solving the model. They also suggested GA- and SA-based heuristics for this solution because proposed problem is of nonlinear integer problem.

To solve an actual aggregate production-planning problem Da Silva and Silva Marins (2014) tried a Fuzzy Goal Programming model (FGP). This model characterizes the production process of ethanol, molasses, sugar, and derivatives in a Brazilian company, and then examines the production of ethanol and sugar. Some of the implications of this investigation include a Fuzzy Goal Programming method for the aggregate production problem in a corporation, to integrate the agricultural, industrial, and logistics phases in a model to help in decision making process during the time between harvests and harvest seasons. An integrated sustainable method was provided by Kafa et al. (2015) for the purpose of partner selection and closed-loop supply chain (CLSC) network configuration. They proposed an exchange between sustainability criteria for supplier and 3PRL provider selection. Kafa et al. also presented a multi-objective mixed-integer programming (MILP) model in order to form CLSC network as well as to selecting the best participants. MILP model decreases the final cost of sourcing and greenhouse gas emissions. But it also increases the final value of reverse logistics, and the number of opportunities for the new jobs. For the purpose of achieving these objectives, based on the sustainability criteria using fuzzy AHP-PROMETHEE approach, appropriate partners are assessed. Afterwards, closed-loop supply chain network is modeled by multi objective mixed-integer linear programming (MILP) model.

The method of weighted max–min for resolving the model is presented to configure reverse logistics network and to select the best sustainable partners. This model provides some guidelines to DM. Analyzing green supplier selections’ Performance indexes on technical, environmental and eco-efficiency grants, Mahdiloo et al. (2015) presented a model and approach. They prove that the previous models are computationally intensive and can’t measure eco-efficiency properly. Not only didn’t they run three different models, but also they employ linear goal programming to accumulate technical, environmental and eco-efficiency objectives into a multiple objective model linear programming (MOLP) and also using data envelopment analysis (DEA) model. The above mentioned model uses a better combination of the technical and environmental efficiency objectives to provide a valid eco-efficiency index of decision-making units (DMUs).
In this model they also deal with the solution of MOLP model. This research has some main contributions as: it is the first case in this ground that examine environmental and eco efficiencies. Second, researchers’ model is developed for the purpose of identification of DMUs as eco-efficient, in the event that the DMU is at the same time technically and environmentally efficient. Third, affirming the restrictions of existing DEA models and methods, they attempted to reduce the number of linear programming from 3xn to n run by means of three models integration, i.e. environmental and eco-efficiencies models into a single MOLP model.

Rezaei and Ortt (2013) in their article form a practical tool for supplier partitioning which concern all partitioning criteria. According to the paper we may classify market partitioning into 3 sub-topics: 1. Consumer partitioning 2. Industrial customer partitioning or demand-side B2B partitioning 3. Supplier partitioning or supply-side B2B partitioning. Though the first two cases are well-founded and enjoy a host of investigations, the third sub-topic enjoys less stress so far. Major result of this study to design a rule governed method for the purpose of partitioning a firm’s suppliers according to two comprehensive decisions: supplier ability and supplier willingness. A sensitivity analysis for such rule governed systems is presented and conducted in order to determine the criteria of most important supplier capabilities and willingness as well as formulate strategies of supplier progress.

The main aim of this study is to provide supplier partitioning with a practical tool. To achieve such a purpose, they use a fuzzy rule governed method for fulfilling a more integrative conceptual framework. The main implication of this research is establishing a rule governed approach to classify the suppliers of a firm based on two above mentioned decisions. Developing and applying an universal sensitivity analysis for fuzzy rule governed systems is a methodological contribution of the study. Wu et al. (2013) presented a new model for vendor evaluation in a supply chain involved in outsourcing risk management named as stochastic fuzzy multi-objective programming model (SFMOP) from the point of view of random uncertainty and fuzzy uncertainty. Wu et al. proposed Utility theory to deal with random data and fuzzy set theory is used to handle fuzzy data. They also analyzed both quantitative and qualitative supplier selection risk factors and received due to a number of outside risk factors affecting outside sourcing, an ideal supplier is much more risky than its indoor counterpart. The researchers also design a supply chain model that composes of three levels: ten suppliers, a core distribution level and ten customers at the third level. A simulated data also extracted to verify the fulfillment of the models. A variety of analyses are implemented in order to cover sensitivity analysis on certain confidence of level, compare between two methods for the proposed model and the three-objective model with case, trade off game analysis and simulate on weight.

E. Ertugrul Karsak, Mehtap Dursun (2013), introduced a methodology acquiring some merits Compared with the other MCDM methods presented in the literature. Such an approach is to incorporate unclear data to be analyzed by linguistic variables bring. And to consider the effects of related less among the features of purchased product, the criteria of supplier selection and the inner dependencies existing among supplier selection Criteria. Along the same lines, to rectify the issue of information loss occurring during the combination of impressive and subjective data as well as to compute different aspects of weights bounds of supplier selection Criteria, such an approach mentioned above, benefits and the pessimistic scenario the DEA model is developed for its high discriminating power. It should be note of, hence, that the presented of decision approach here is to prevent the tough process of fuzzy number ranking resulting in achieving contradictory outcomes as various models of fuzzy number ranking are applied.

Memnon et al. (2013) believe the problem of supplier Selection to be a multi-Objective Optimization Problem (MOP) in which price minimization, rejections and lead-time minimization are considered as the three important objectives. This paper aims to achieve some levels of consistency among different objectives which take two different cases into consideration: 1. The crisp mop which the objectives goals are predetermined in, and 2. The fuzzy MOP that the objectives weights are predetermined in. For both cases, a normalized goal programming approach is developed and, then, is experimented and an imperative analysis is conducted to compare the effectiveness of the proposed method. This comparative analysis includes
weighted goal programming, Compromise programming, TOPSIS, weighted objectives, minimum-
maximum goal programming & weighted min-max models and reveals that the four proposed models seek to attain the desired consistency among all the objectives.
Huang et al. (2011), used a two-stage algorithm deal with the issue of product’s part change. At first
analytical hierarchy process (AHP) used to select the module in a product and secondly after changing the
module, the supplier selection process including a mathematical programming model initiated to select the best suppliers using Particle Swarm optimization (PSO) algorithm. Vahdani et al. (2012), presented artificial
intelligence (AI) method in order to improve the decision making for a supply chain of the performance data
in indoor industry. In this paper the used approach locally linear neuro-fuzzy (LLNF) can predict the efficiency ranking of suppliers.
This model is trained by a locally linear model tree (LOLIMOT) learning algorithm and explains its performance: multi-layer perception (MLP) neural network, radial basis function (RBF) neural network and least square-support vector (LS-SVM). By comparing the data in cosmetics industry in Iran with computational results from the proposed model has better performance from the three techniques those mentioned above.
Woo and Saghiri (2011), developed a fuzzy multiple-objective mixed-integer programming model and analyze the order allocation problems by considering ambiguous aspects of decision-making problems. The model contains three main parts of supply chain those based on: the purchasing organization, suppliers, and third-party logistics providers (3PL).
The proposed model contains a buyer company, a 3Pl and multiple suppliers with limited capacity for different required products. In this problem the three considered objective include ordering cost, inventory cost and purchasing costs and in order to reach less complexity the model transferred to the single-objective model by considering its multi objective aspects.
Amid et al. (2009) presented a three objective model for the supplier selection problem. These three objective functions describe by minimizing the net cost, minimizing the net rejected items and maximizing the net late deliveries. The model should satisfy capacity and demand requirement constraints related to supply chain. Therefore, the model assumes that there is uncertainty in input data and varying importance of criteria. The mentioned model manages supply chain performance on cost, quality, service, etc. fuzzy weighted additive and mixed integer linear programming help to solve this model. The mentioned methods also consider inaccuracy in information and ascertain the order quantities for each supplier based on price breaks.
Haleh and Hamidi (2015) presented a model describing by fuzzy multi-criterion for assigning orders to suppliers (This process comes after supplier selection and evaluation). The fuzzy approach is adopted to overcome the vagueness of the information due to the uncertainty of them and also MCDM methods are used to allocate suitable shares of orders to the best suppliers. This model developed in both single and multi-period concurrently. By considering the supplier’s capacity, price, quality and risk constraints, the order allocation problem become more complicated. so a fuzzy linear multi-objective programming model is used to support order allocation decisions with tangible and intangible factors and intend to optimize the price, quality and risk objectives and satisfy constraints such as logistics costs, suppliers’ capacity, supply chain demand, risk, etc. AHP method considered useful to this problem, also this approach with defined constraints produce optimum solution for the problem.
Gupta et al. (2015) focused on the analysis of imprecise information regarding many vital parameters for a multi objective multi-item vendor selection-order allocation problem considering price-breaks in the work. They used quantitative and qualitative criteria and consider the economic, technological, social, environmental factors, and the price-breaks. In this research a new model was developed integrating fuzzy multi-objective integer linear programming and analytic hierarchy process techniques. A weighted possibility programming approach used to solve this problem has the ability to time minimized / maximized the best scenario and the worst scenario and the most similar scenario at the same. Main contribution of the study has two parts: the model for the VSP that uses the economic, technological, social, and environmental
issues and WPP solution approach. One of the contributions of the paper is improving the possibility programming approach for the solving of fuzzy VSP.

A model with 5 goals was developed by Seifbarghy et al. (2011). This goals include minimizing the transaction costs of purchasing from suppliers and minimization of the purchasing cost, rejected units, lately delivered units as well as maximization of the evaluation scores of the selected suppliers. They used the simple weighting method to convert the multi-objective model into a single-objective one; also, they employed two meta-heuristic methods for solving the mentioned model. Arikan (2013) examined a multiple sourcing supplier selection problem as a multiple objective linear programming problem with fuzzy demand level. This paper presented three objective functions including minimizing the total costs, maximizing the total quality and maximizing the service level of purchased items.

A novel interactive solution procedure is provided to solve the problem, the procedure which integrates three well-known fuzzy mathematical models. This procedure assists the DM for determining objectives’ aspiration levels. Impreciseness is managed by the proposed method via suggested fuzzy mathematical programming models in the literature. Moreover, interactivity of the approach allows the DM to incorporate his/her preferences during the solution process. A multi-objective fuzzy linear programming model for a GSS problem was developed by Bakeshlou et al. (2014) that has 17 criteria, while for solving it a hybrid fuzzy multi objective decision making (MODM) was used. Main goal of the study is selecting the best set of suppliers in terms of optimal allocation of order quantities while demand and supplier’s capacity are restricted. This study presents a model for supplier selection provided by Amid et al. (2011) concerning Kannan et al. (2013) for a GSS problem formulated into fuzzy multi-objective linear programming. One of the innovations of this study was providing an SSP into green case and order allocation problem under fuzzy situations while suppliers’ capacity and demand over the period are constrained. The second implication was to hybridize the solution algorithm. This study also provided a fuzzy hybrid MODM to optimize a green multi-sourcing supplier selection a fuzzy multi-objective linear programming (MOLP) model provided a near-optimal solution using the weighted max–min method.

Francisco da Silva et al. (2013) studied the aggregate production planning of a Brazilian sugar and ethanol milling company. This problem is formulated considering a Multi-Choice Mixed Integer model and Goal Programming model (MCMIP). The MCMIGP model presents a helpful understanding for decision makers and assists them to comprehend better the considered variables and important issues. The application of this model and the great advantages of this model can be seen as a help to aid administrative managers to make better decisions regarding problems of sugar and ethanol mills. The supplier selection process in a company in the Chinese Dairy Industry was investigated by Ren et al. (2016). In this case study the methodology includes seven interviews with managers and employees. This article talks about the similarities and differences between the research findings and literature review. The conducted interviews included Company’s Operations Manager, Purchasing Manager, Supply Chain Manager and four staff in the Purchasing department. The interviews’ directions were: the company’s supplier selection criteria, whether the company has purchasing portfolio analysis, the company’s current sourced raw materials for dairy products, general SSP of the company, detailed information about each stage of SSP in the company, the place that the analysis before company sourcing has spent, the way of the company to conducts the choosing supplier and treat with the suppliers, presence problems probability in the company’s current SSP, and the company’s routine, critical, bottleneck and leverage products. It is worth to mention that the results of this study cannot be generalized to other dairy companies.

2.2 The Fuzzy AHP technique

A comparative analysis of two methods, Fuzzy AHP and the Fuzzy TOPSIS, was presented by Junior et al. (2014) in the context of supplier selection decision making. Conducted comparison is based on several factors: sufficiency of changes upon alternatives or criteria; computational complexity; agility of the decision making; the number of alternative suppliers and criteria; sufficiency of support group decision making; and
to model uncertainty. The agility and computational complexity evaluation are achieved with 64 tests that are concerned with supplier selection scenarios including 2 to 9 alternatives and criteria. The main implication of this research is proposition of a set of seven factors that evaluates the MCDM methods. From such a point of view, we can utilize this set as a framework for assessing the sufficiency of other methods in this ground. An AHP-based model was developed by Bruno et al. (2012) to address the problem of supplier selection to grasp the meaning of the determinants of dichotomy between theoretical approach and empirical application. It is also used in a case study. The identification of strengths and weaknesses of such models is carried out by the implementation process of the proposed methodology, covering the supplier evaluation problem as well as emphasizing barriers preventing to adopt such methods.

In a research an integrated approach of clustering and multi criteria decision making to solve the problem of supplier selection was proposed by Azadnia et al. (2012). An integrated method of self-organizing map and MCDM techniques has been presented in this research to cope with sustainable supplier selection problem. Initially for determining the weights of sustainable criteria and sub-criteria in terms of supplier selection problem, FAHP was employed. Then, in order to grouping the suppliers into different groups, Self-Organization Maps (SOM) neural network has been used. The process of sustainable supplier selection was done by decreasing data dimension and was facilitated by clustering the suppliers that was used in MCDM methods. When different segment of suppliers are available in the market, the above mentioned point also helps companies’ managers in better decision. Clustering analysis may provide the problem of sustainable supplier selection with a prequalification. And at the end, it is worth to mention that TOPSIS technique, has been implied in order to rank and select the best cluster of suppliers and the best supplier. Bhattacharya et al. (2010), used cardinal and ordinal preferences for evaluation of suppliers considering cost factors and integrating the quality function deployment technique (QFD) with analytic hierarchy process (AHP).

Supplier selection depends on both customer requirements and engineering requirements. Engineering approach was used simultaneously to integrate QFD and AHP in combination with CFM cost factors for selecting suppliers under multiple and contrary criteria in the form of supply-chain. The importance of the proposed method was determined with regard to parameters as decision weight of the objective function. The model allows for decision for imagining respond of decision variables regard to changing on decision weights.

Shidpour et al. (2013) presented a three-dimensional concurrent engineering (3D-CE) approach. In this research to solve the problem they help from MCDM approach such as FAHP and TOPSIS and finally integration of these methods. The main goal of this study is to ascertain the best design alternative, assembly process and suppliers currently. In the first phases of new product introduction, this study considers various supply chain strategies and quantitative criteria. In the multi objective planning different objectives were used that include four functions such as cost, time-to-market, customer satisfaction, and dependency risk. Also in this method Take advantage of qualitative parameters of design consist of functional analysis, ergonomics, aesthetics and serviceability. using The qualitative and quantitative values derived of the multi-objective programming in build the TOPSIS method build the best solution and the importance of these all criteria is determined by FAHP. There is some limitation in this method like not considering some of the important cost parameters and inter-dependency between parameters and ignoring some important life cycle costs like service cost. A sensitivity analysis of parameters that affect the optimal solution was done by using visual studio programming.

Rezaei et al. (2014) investigated supplier selection in the airline retail industry and solved it with a two-stage methodology. In first stage in order to diminish the elementary set of available suppliers, a conjunctive screening method is used. In the second stage suppliers are analyzed with due attention to the main criteria and sub-criteria by employing the fuzzy AHP approach. The decision-maker’s preferences and introduced method rank the supplier and at the end select the most suitable supplier(s). Batuhan and Selcuk (2015) developed the first multi-item solution for Supplier selection problem. This problem called multi-item, multi-supplier problem. The problem is more sophisticated with various items and suppliers and cannot provide
all types of items individually. Therefore, using the quantity discounts make the problem more complicated. Also existence of numerous quantitative or qualitative criteria, choosing the criteria and various solution approaches to solve the model make the problem more difficult. In this multi-item/multi-supplier model with all-unit quantity discounts allowed to select the best suppliers a new approach was developed comprise integrated Fuzzy AHP and Mixed Integer Linear Programming. The integrated Fuzzy AHP was used to determine the relative weights of different criteria. Progress in solving with mentioned approach, at first stage, the relative weights of each criterion for each type of item should be determined by F-AHP technique and the outputs of first stage used as inputs in second stage to specify the suppliers and provide the quantities by MILP model.

Hu and Yu (2015) investigated selection problem considering electronic contract manufacturer with application of the voting method and goal programming (GP). The model identifies electronic contract manufacturers (ECMs) with the highest potential to satisfy a manufacturer's demands continuously. By considering various criteria in the decision-making process this problem became a complicated MCDM problem and integration of the AHP and ANP and the voting method and goal programming technique is used to solve the matter. In this study the optimum outsourcing quantities for the ECMs is determined considering both tangible and intangible factors involved in rating the ECMs. The obtained results of the mentioned process are used by GP models to specify the optimal order quantities for the ECMs.

Rahiminezhad et al. (2016) developed a model to select supplier selection using integrated Balanced Scorecard–Fuzzy Analytic Hierarchical Process. They used this model in the automotive industry. In this study, the Measures with help of a literature survey were collected and validated with nominal group technique (NGT) and a fuzzy AHP to choose the best supplier. this research worked out only on Iran’s industries with the goal of select the best supplier for automotive industry with using a fuzzy AHP and incorporated all of performance measures simultaneously. In this research a new idea was invented for gathering the explicit measures developed in the process of supplier selection in automotive industries to reduce the confusion of existence a lot of performance measures. considering the hypothetical and methodological point of view this study also presented a new approach for selecting the supplier in automotive manufacturers under specific condition and measures while very few researches have been already managed this situation.

As a means for the selection of the best supplier under CSR environment, the significance of 7 criteria has been analyzed by Lei Xu et al. (2013). These criteria were pollution, female gender labor, human rights issues, safeguarding mechanisms, long working hours, underage labor and organizational legal responsibilities. Other sub-criteria also were included which were relevant to the issue. The process of hierarchy analytical determined the importance of the criteria and sub criteria used in the CSR-based supplier selection. In 2016 an integrated fuzzy-analytical hierarchy process (AHP) was applied by Kharat et al. to municipal solid waste (MSW) landfill site selection problem. To make pairwise comparisons of criteria for assigning weights and ranking them, the fuzzy-analytic hierarchy process was employed, but to rank the alternatives F-TOPSIS was employed. In this study it was found that fuzzy-AHP–TOPSIS-based methodology will be a powerful guiding tool for municipal solid waste planners. The utilized methodology successfully considers the uncertain, subjective and linguistic data from expert opinions. The research presents a systematic decision making process for the purpose of selecting an alternative municipal solid waste disposal location in the city of Mumbai.

Applying a new integrated method to Supplier selection in 2016 was suggested by Zanjirchi et al. this method was based on AHP and TOPSIS methods. In this study to solve, the combination of AHP and TOPSIS method is used and TOPSIS method uses AHP’s result weights as input weights. For determining the weights of the criteria by decision makers AHP method is employed, then TOPSIS method determines the rankings of Suppliers. To derive criteria weights with aid of Analytical Hierarchy Process (AHP), Linguistic variable associate with Interval Valued Neutrosophic Sets (IVNS) are employed. This study provided a new hybrid method that nixes AHP and TOPSIS for the purpose of finding the best supplier appropriate for the present
practical scenario. IVNS considering Linguistic Variables were employed to obtain criteria weights with AHP.

2.3. The Fuzzy TOPSIS technique

Based on the works’ literature review and experts’ discussion related to the Indian automobile industries located at Delhi region, Tyagi et al. (2015) checked out 7 criteria and 3 alternatives. These criteria were waste minimization, awareness about green concept, saving energy, reuse of hazardous waste, design for environment, information sharing regarding environmental regulations and proper mode of transport. 3 alternatives were: suppliers, web based technologies and advanced manufacturing technologies. Tyagi et al. provided a model of hierarchy type performance and also employed Fuzzy TOPSIS method in order to choose the best alternatives for enhancing the GSCM system’s performance. Jaroslaw & Watarobeski (2016) offered a framework defining input information with having a methodological background demand by decision- centered processes by using the multi- criteria decision analysis (MCDA) methodology to introduction a dynamic approach, to the numerical and linguistic data obtained? From different sources; hence the fuzzy TOPSIS method was selected the existing criteria and the proposed framework present models focusing more on decision makers, current preference and valid data as well. Roshandel et al. (2013) considered the hierarchical fuzzy TPOSIS as a practical & appropriate tool to rate the candidate suppliers based their general overall performance in relation to multiple criteria. To removing the supplier selection management & decision problems, ambiguities and complexities, the fuzzy theory was adopted for supplier selection & evaluation problem. To find a better solution for such problems and to apply the suggested methodology, the study was conducted. The methodology employed. In lines with AHP, TOPSIS, fuzzy TOPSIS & the other MADM teaching for finding a positive ideal solution ranking order ability, evaluation the criteria correctly and recognizably. To handle multi- attribute decision. Making (MADM) problems in intervolled intuitionistic fuzzy seething, Zhoujing and Kevin et al. (2011) propose an approach in which both typos of evaluation of alternatives on attributes and attribute weights are benefited ad interval- valued intuitionistic fuzzy numbers (IVIFNS). Besides, to place IVIFN decision data appropriately, the concept of relative closeness has been extended to interval valued and fractional programming models have been developed on the basis of TOPSIS. Zhongliang (2013) provided a MAGDM methodology and an extended TOPSIS technique to assess the interval weights of BMS, to determine the overall performance of the alternatives as well as rank their preference order to compare it with another method in group decision- making, and to show the technical development of the reported method. In addition, to test the effectiveness & practicality of the offered method, a real- life application for supplier selection is considered as necessary. Kannan et al (2013) Pay much attention to the criteria which are of great value environmentally, socially, & economically to evaluate suppliers according to the triple bottom – line concept. Considering all three dimensions at the same time in business operations generates the desirable results. In such a framework, the sustainability criteria should also be taken into consideration for supplier selection decision. To evaluate sustainability, the experts offer linguistic ratings to the criteria and the alternatives as well. For evaluating the general performance score and linguistic rating, the fuzzy TOPSIS is applied. Chamodrakas et al. (2009), proposed a new fuzzy method for customers analyzing. The issue of uncertainty in the problem of customer analyzing considered qualitative criteria acquired from the Yong method for converting the weight of criteria and rating the suppliers into crisp numbers. After that by the modified TOPSIS method behavioral pattern of decision maker should be mixed with the compromise principle. A new model for integrating the performance of TOPSIS based on fuzzy sets represent the closest and furthest from the ideal state using fuzzy communications class defining the aggregating function and membership function with a numerical example was investigated. Deng and Chan (2011), presented a new MCDM method using fuzzy set theory (FST) and Dempster Shafer theory of evidence (DST) for order preference by similarity to an ideal solution (TOPSIS). In this study, the distance between the ideal solution and the
negative ideal solution specify by the basic probability assignments (BPA). A supplier selection example for
the use of the proposed was represented and the results show the effectiveness of the proposed method.
Chen and Yang (2011), proposed a new method for multiple group decision making (MADM), using the
constrained fuzzy analytic hierarchy process (CFAHP), FTOPSIS, and the bound evaluation method and
other conversion skills to efficiently solve complex MAGDM problem and to find suitable decisions. The
fuzzy Topsis is used to rank the alternatives. The proposed algorithm reduced unknown level of fuzzy
information and gives more accurate weights. The sensitivity analysis was performed in two cases and the
stability, performance and practicality of the algorithm was shown. Zouggari and Benyoucef (2012), adopted
two step decision approach and multiple criteria for selecting suppliers with order allocation. For dynamic
supply chains to cope market variations at first a fuzzy-AHP method is used for supplier selection through
classes, including: performance strategy, quality of service, innovation and risk. Secondly, using
simulation the criteria according to fuzzy TOPSIS technique, suppliers evaluated considering price, quality
and delivery criteria and based the achieved results implemented order allocation.
Chen et al. (2006) proposed a new approach to survey the supplier selection problem in supply chain system
based on fuzzy decision-making. Factor that should be considered to determine suitable suppliers consist of
the quantitative and qualitative factors such as quality, price, and flexibility and delivery performance. In
this paper in order to assess the ratings and weights for these factors, linguistic values are used that can be
expressed in trapezoidal or triangular fuzzy numbers. Also develop a hierarchy MCDM model based on
fuzzy-sets theory. Ranking the order of all suppliers, a closeness coefficient is defined based on TOPSIS
approach to calculate the distances to the both fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal
solution (FNIS) currently. This proposed method can be simply used in the assessment of all management
decision problems.
Onut and et al. (2009) presented a supplier evaluation approach applying ANP and TOPSIS in a company
in the GSM sector in Turkey. This study developed under the fuzzy condition so ambiguity and individuality
are applied with linguistic terms formulated by triangular fuzzy numbers. because of the importance of
selection the proper supplier and a multi-criteria problem which includes both tangible and intangible factors,
the fuzzy sets was used to characterize the uncertainties in different factors and simplify the intricate
structure of the decision making .also (ANP) can evaluate the best suppliers Technically owing to the
interdependence and feedbacks caused by the reciprocal impress of the criteria and FANP make the problem
more simple by its weights. The TOPSIS and fuzzy TOPSIS method is suitable for this problem and attribute
values showed by fuzzy numbers.
Liao and Kao (2011) developed combined fuzzy techniques to order ranking. Topsis and multi-choice goal
programming (MCGP) approach applied to present ideal solution for the multi-sourcing supplier selection
considering both tangible and intangible criteria .in this proposed approach solving procedure is as follow,
first trapezoidal fuzzy numbers represent the linguistic values and applied to evaluate weights and ranking
of supplier selection criteria. Then by using a hierarchy multi-model based on fuzzy set theory and fuzzy
positive and negative-ideal solutions, the model can be able to find each supplier’s proximity factor. Finally,
a MCGP model made based on the tangible limitation linked the buyer and its suppliers to present the final
solution and devote order qualities to each supplier.
Buyukozkan and Cifci (2012) presented an analyzing approach related to green supply chain management
(GSCM). In this study a new hybrid fuzzy MCDM and fuzzy DEMATEL and ANP fuzzy TOPSIS is used
and also fuzzy TOPSIS method has the main role to select the best solution of the problem. Representing an
analyzing method to assess the suitability of suppliers for an organization is the original object of the model.
A real case study the Ford Otosan is used in order to validate the model and provides additional insights for
research and practical applications. Orji and Wei (2015) developed a new approach using fuzzy logic and
systems dynamics modeling for selecting and monitoring appropriate supplier operation in supply chain
systems with securing the status of suppliers for a long time. The model present a good view of supplier
treatment progression during the time and chose the best possible deserving supplier. Also a fuzzy TOPSIS
approach compares the achieved results from the developed systems dynamics model. The mentioned method can be used to any green manufacturing conditions ignoring the number of alternatives and related stability criteria. In expanding of the systems dynamic model, there is probability of time and cost resources requirement but before installation use of the model becomes less requirement.

Arabzad et al. (2014) provided supplier selection and order allocation problem with a model that had two phases. Firstly, based on the qualitative and quantitative criteria result from strengths, weaknesses, opportunities, and threats (SWOT) analysis suppliers are evaluated. Afterwards, fuzzy logic is provided for the purpose of order preference by similarity to ideal solution (TOPSIS) technique in order to evaluate criteria weights. And finally, at the same time, a case study is used to validate the proposed model. Arabzad et al. paper was the expansion of the work of Amin et al. However, there are some solid differences. First the researchers of this paper consider the importance weight of decision-makers (DMs). Second, since the model employed FTOPSIS to determine the importance weight of the criteria and alternatives, it would be more accurate. Third, while for determining weights of internal and external criteria in mathematical modeling they consider type of the parts, SWOT analysis is used to determine evaluation criteria in this paper. The major features of this model can be stated as: considering multi-supplier, multi-criterion, and multi-part in the proposed model, taking into account the internal and external criteria, proposing a model which simultaneously accomplishes supplier selection and order allocation, considering policies of the company, determining criteria from strategic point of view, and applying fuzzy logic to deal with uncertainty of human’s opinions.

In 2012 a paper presented by Sharma et al. that coped with an integrative method regarding Taguchi’s loss function, Technique for Order preference by similarity to ideal solution (TOPSIS) and Multi criteria goal programming. The model is divided into 3 phases. In first phase, via using Taguchi’s loss function, the quality losses are identified. Suitable factors are identified with different weights from TOPSIS in the second phase and finally in the third phase for the purpose if identifying the best performing supplier with the weights and the loss associates a goal programming model is developed. The goal of this study is integrating different criteria levels for identifying better performing supplier. By using Taguchi loss function, TOPSIS and GP an integrative approach was proposed to solve the supplier selection problem.

2.4. The LINMAP technique
Shu-Ping Wana, Deng-Feng Li (2013) aim to make the linear programming technique for multidimensional analysis of preference (LITMAP) to solve the heterogenous MADM problems. In this study DMS first choice is given via pair comparisons of alternative with delay degrees represented as IFS. The IF quality and the quality of indexes are explained built on the pair –work comparison of the alternative. every of possible choice is checked out the basis of the range it has in relation to a fuzzy ideal solution (FTS) know as a theory according to the defined IF consistency and due to the consistency indices a new fuzzy mathematical programming model has been explained and advanced.

2.5. The DEMATEL technique
James (2014) By using a fuzzy integral- based model, could analyze supplier evaluation. This model was modified and used in this study for same reasons including: 1. The traditional models suppose and accept the criteria to have an independent and superior Structure, but in real world, decisions are subject to changes the present study applied the DEMATEL method to create a network relationship. 2. So, the DEMATEL- based and method is used to get the influencing weights so that it can eradicate the comparisons which are time-consuming in the original AMP. This paper used VIK or notion to transform the performance levels into weighed gaps, enabling a decision- maker to eliminate gaps in alternatives so that it will reach the aspiration level, though; The center of attention a MCDM application has shifted away from rating & selecting at the time of determining more favorable approaches to modify & develop the optimization of the current methods. Abdollahi et al. (2014) proposed a product-related and organization-related model for supplier
selection. This model considers mentioned characteristics to become more ambitious in the bazaar and more bendable in order to overwhelm possible something that made differences in places people etc. This study mentions two groups of lean and agile suppliers and an advisor for supplier relationship management (SRM) is used related to these suppliers. Combining of multiple suppliers with help of a DEMATEL-ANP-DEA model result in determining the relative efficiencies and ANP is used to determine the weight of each criterion for each alternative (supplier). Also DEA approach employ to rank the supplier according score in each criterion. Furthermore, fuzzy decision making trial and evaluation laboratory (DEMATEL) is applied to designate the accurate interdependencies between the proposed criteria.

2.6. The VIKOR technique
Sanayei et al. (2010) used VIKOR method for solving hierarchical MCDM problems using both qualitative and quantitative criteria for the intention to evaluate, rate the weight of sellers in a blurred atmosphere. An algebraic instance was introduced to demonstrate the suggested item. Due to the flexibility of this method it can be used in combination with other methods and mathematical planning to select suppliers in an environment of multiple sources and to help other management decisions. Chen and Wang (2009), applied an integrated VIKOR fuzzy method for multi-criteria fuzzy decision-making for evaluating and allocate suppliers or vendors, the realistic and analytical method will be provided for cultivating the best alternatives and an agreement for solving problems under each of selection criteria. The conclusion which illustrate proposed actions was capable of gaining important benefit through the spatially explicit evaluation of complex and voluminous data sets, which are not same to know as a suitable answer for this problem by the amount of groups and different majority and less separated regret of opponent. You et al. (2015) investigated an extended VIKOR method for supplier selection problem under multi-criteria and interval 2-tuple semantic information and also doubtable and incomplete information condition, the mentioned way put to cope the multiple different criteria and choose the best suppliers. The VIKOR method is capable of modeling the variety and doubt of the evaluation information make by decisive people and mention conflicting quantitative and qualitative criteria as well in fact through applications synchronously but cannot prevent distortion of information and loss it.

2.7. The ELECTRE technique
Zak (2015) analyzed the suppliers’ selection problems and formulated it in distinct industries under multiple criteria ranking condition. The study intends to find similarities and differences in the assessment processes of suppliers in different industries. In this research the applied way is a basis of principles of multiple criteria analysis. The AHP and The ELECTRE methods used to get the results. The experimental results show that they are placed at the upper parts of the rankings, at least at the top position in one of them; they do not have critical weak points and ambiguous trade-offs; their evaluations are high on many parameters, including the most important criteria.

2.8. The Neural Network (NN) technique
The aim of decisive people of this study about the evaluating the supplier as well as in the selection problem, Ozkan and Inal (2014) set up Adaptive Neuro-Fuzzy Inference System (ANFIS) well. In this method it is proposed that determining a reliable supplier via this approach will help decision makers. In order to achieve this goal, ANFIS is examined for many types of tests such as data sets whose variables are suppliers and their points obtained from a study case named as neural network (NN) application for fuzzy multi criteria decision making model. These two data sets are employed in two stages of preparation and examining separately and with Mean Squared Errors (MSEs) in the model. According to the comparative analysis, ANFIS leads to better results based on the linear regression analysis (R-value) and Mean Square Error (MSE). Fahimnia, et al. (2015) There have been many papers published on the about green supply chain
management, mostly, on the win the pasted cade; however, a comprehensive bibliometric & network analysis to find the influential ones and to discuss them in research gatherings is needed.

2.9. The Analytic Network Process (ANP) technique

Lin (2012) compiled this article to deal with the multiple criteria and basic doubt in supplier collection and paper to make (everything) balanced in order to (the fuzzy analytic network process (FANP) method determine the best quality is well as managing in consistent and unsure argument so FANP is mixed with (FMOLP) to pick the suitable suppliers. The proposed model is different from other integrated methods in terms of allowing integration of DMs inexact hope levels for allotting read quantity of arrangement to a given supplier. In addition to this, the model may assist firms monitor suppliers to prevent subjective decision made by human and to enhance relationships with their selected suppliers.

Gurbuz et al. (2012), explored the hard work of mixture multi criteria decision making (MCDM) procedure, for the examination of varied ERP alternatives, according to three methodologies: analytic network process (ANP), Choquet Integral (CI) and measuring attractiveness by a categorical based evaluation technique (MACBETH). ERP selection criteria categorized into three main sets: vendor related criteria (VRC), customer related criteria (CRC), and software related criteria (SRC). And the priority and the relation between options determined by the ANP method under the dependencies evaluate criteria. MACBETH technique was used for intermission algebraic graduated systems are basis of qualitative and CI method for determining conjunctive or dis conjunctive of criteria were used. And finally ERP rating according to performance of points was done. A case study of ERP software for the ranking was done. Dey et al. (2014), demonstrated strategic Accomplishment examination of a UK–based manufacturing organization utilizing an integrated analytical frame work leading factors like (controller) mode, uncertain management ,incidental and social mode and back ward factor for supplier examination using an (systematic ) arranged method proposed .To know those factors the valuation of the job deployment and the checking order method for examination was used for real –life case is made on action research.

Hashemi et al. (2014) Projected an inclusive green supplier choosing model apply financial and incidental basis. The general goal of this study is developing a using ANP and GRA developed a gray-based green supplier selection that is a very impotent goal in this study. The ANP method can cope with relation among the basis and GRA characterize the uncertainties inherent in supplier selection decisions in a better way. The mentioned new approach makes participating of decision makers in the evaluation process possible and employ linguistic evaluation in the process. A new a new approach based on fuzzy set theory and analytic network process (FANP) in 2015 was developed by Zhangin in order to cover address both unsure information included and the association among the feature finally, this research along with an examination describes the application of this model for a real–work supplier selection scenario. Compared to accessible method, authors demonstrate the efficiency of the advanced model. This method supplies researches with a recent perception info trouble of supplier in a broad sense.

A fuzzy analytic network process model for evaluating different features of suppliers was developed by He- Yau Kang et al. (2010). They Consulted with specialists to enable the advanced model include the feedback and interdependency of determinant in a network , and the factors are pair –wise compared under ANP (FANP) model that presents the fuzzy logic into the pair-wise contrast in the ANP and the super matrix idea , to have an answer for this question of supplier selection , this model also regards the difficulty of the problem of supplier selection areal .determines vital aspect that are acknowledged in investigations. The result of the limit super matrix shows the best supplier which has the suitable complete. The relative importance of the factors for evaluating suppliers also is roved by calculations.

A supplier evaluation approach that was in compliance with on the analytic network process (APN) and fuzzy synthetic examination under a fuzzy atmosphere was developed by Pang et al. (2011). Fuzzy synthetic evaluation is employed for the purpose of selecting a supplier alternative and the Fuzzy ANP (FANP) method calculates importance of the criteria weights. Afterwards, the aim of examination and choosing the
best suppliers mixed FANP and fuzzy synthetic examination methodology is projected. We see that in this study an integrated method to evaluate suppliers and facilitate optimal order allocations was proposed consists of two stages (eight steps). The very first step, the FANP method has been experienced of measuring the value of suppliers a fuzzy understanding examination method was used. In such a method fuzzy numbers make the values of feathers. By meaning of using FANP firstly, fuzzy numbers and the first concern about weight of the selection criteria were conducted. In such a method, the attribute values are provided by fuzzy numbers. By means of using FANP firstly fuzzy numbers and the priority weight of the selection criteria were determined. Afterwards, for ranking the alternatives FANP criteria weights are inserted to the fuzzy synthetic evaluation methodology.

The study conducted by Chung (2016) helps to organize a harmless supplier s selection and helpful tools by making an ANP & an IPA mixed in order to gain sustainable management for green supply chains. At first to select suppliers for green supplier selection the ANP was employed. Then, for the purpose of performance analysis and improvement for green supplier guidance the IPA was employed. The final results of this study were: a) a total 11 performance examination criteria is consisted by the harmless supplier choices criteria in terms of three measure of movement, competence, environmental consciousness, b) the five top among all green criteria included environmental benefits, environmental regulation, finance, technological competence and delivery time. c) To analyze the basis of acceptation and the level of supplier performance and to make a suggestion for supplies on first improvements, an IPA is employed: (d) to make the green supplier selection and guidance mechanisms easier and increase the efficiency of supplier management. It is concerned that ANP and IPA should be integrated in the applications.

2.10. Green and Sustainable Supply Chain Management (GSSCM)

In Taiwan, Tseng and Chiu (2013) described the case of a printed circuit board manufacturer which wishes to fulfill green supply chain management (GSCM) and chooses a green supplier to meet the required criteria. This query determined the appropriate environmental and non-environmental GSCM criteria and developed the following selection method: a) evaluation of the weights of the requirements and alternatives illustrated by qualitative and quantitative information; b) arranging the alternative suppliers through a grey relational analysis. This research goals to conclude semantic preferences in the process of selecting a different supplier via a projected model. The main focus of this investigation was on the development of quantitative evaluation measures in uncertainty by means of fuzzy set theory. Finally, 18 criteria, qualitative and quantitative, should be taken in account and evaluated simultaneously.

For the purpose of dealing with different problem in semantic preferences, quantitative data and incomplete information, this research study proposes a hybrid MCDM method. All in all, this investigation contributes to the related works by: a) providing a GSCM hierarchical framework that merges environmental and non-environmental SCM criteria in a single framework; b) providing, built on the specialist qualitative preferences as well as quantitative data, valid and reliable measures for the GSCM; c) developing a hybrid method to have an answer this situation of supplier selection. The aim of resolving the projected GSCM criteria in an OEM firm the empirical example of green supplier selection problem has been used. This model can be used to assessment and determination of a firm’s GSCM supplier selection.

The gap in tenability examination of suppliers of medical tool manufacturing was addressed by Ghadimi and Heaveya (2014) through using an efficient Fuzzy Inference System (FIS). The major stress of this paper deals with the process of supplier selection in the medical device manufacturing industry domain. The most important criteria of supplier selection in this regard has been gathered and classified. it is the main part of the study. An effective FIS is to measure the data and information in terms of the sub criteria. It is worth mentioning that this article is a sub section of a five-phase framework for specifying uncertainty in the supplier selection and order allocation by a Multi-Agent System (MAS) method. Kannan et al. (2014) presented a model to select choose the suitable pant of green supplier. The applied technique called Fuzzy Axiomatic Design (FAD) that is one of (MCDM) approach. Because of the main point of this Immeasurable
and unfinished information, judgment the mentioned approach is the appropriate solution. The model and methodology analyze the suppliers who did not meet the company’s requirements and solve the MCDM and selects the best green supplier then assign the most appropriate alternative supplier for the company requirement.

Azadi et al. (2015) propose an integrated DEA improved Russell measure (ERM) model in fuzzy situation to choose the suitable suppliers. finding an adapted and persuasive supplier in acceptability context is the aim of this research in order to go up the challenging advantage of companies this problem should be considered because it is the very first of the most vital issues. also a case in this research was introduced to be exhibited the ability of the projected method for acceptable supplier selection problem in a resin production company and show that the proposed model can measure effectiveness, efficiency, and productivity in uncertain environment with different α levels. Using the mentioned model, the decision makers will be able to deal with economic, social, and environmental factors while selecting sustainable suppliers.

2.11. Multi-Criteria Group Decision Making (MCGDM)

An Atanassov’s interval-valued intuitionistic fuzzy outranking choice method for the purpose of solving the problems of Multi-criteria group decision making (MCGDM) was developed by Xu and Shen (2014). They suggested to a deterioration for Atanassov’s interval-valued intuitionistic fuzzy set (AIVIFS) and proposed a model which is employed to determine the objective criteria weights of the alternatives, and afterwards extended the EIECTRE I method to have concern for the decision makers’ Atanassov’s interval-valued intuitionistic fuzzy number (AIVIFN) assessment information. This article has some contributions as: a) providing an entropy measure for AIVIFS as well as establishing an entropy weight model for determining objective criterion weights; b) classifying different types of concordance and discordance sets by AIVIFN characteristics in order to correspond a red situation for making decision and provided graphical representation of the outranking relations for determining appropriate action; c) To extend the method of AIVIF outranking choice in order to take into consideration account group decision-making techniques and providing two superiority indexes; d) proposing a provider election example to clarify each pants of the projected method. This proposed method is flexible and is able to be applied to other problems of managerial decision-making.

For the purpose of selecting and evaluating green supplier to improve GSCM initiatives, a fuzzy multi criteria approach was demonstrated by Shen et al. (2013). The criteria for evaluating the green supplier have been identified based on the green supplier selection literature survey that consists of industrial and environmental experts’ ideas and managerial judgments. Shen et al. for quantify linguistic variables which state the subjective judgment of evaluators introduced fuzzy numbers and for the purpose of aggregating the ratings and generating an overall performance score measuring each supplier’s environmental performance fuzzy TOPSIS was used. At the end, a sensitivity analysis was conducted in order to identify the impact of criteria weights on the decision making. This analysis showed that the final decision is not sensitive to items used in the evaluation.

Qi et al. (2015), focused on the multiple attribute decision making problems and represented effective group decision making (MAGDM) with unknown attribute under interval-valued intuitionistic fuzzy environment (IVIFS). For make uncertain decision information the tool of IVIFSs employed. At first presented cross-entropy for IVIFSs according to this tool an optimization model for determining unknown attribute weight by considering the divergence of attribute assessments from the most fuzzy number in IVIFSs and the derivation between attribute assessments and another comprehensive algorithm has been developed for determining unknown expert weights by considering divergence of decision matrices from positive or negative ideal decision matrix and similarity degree between individual decision matrices so proposed a typical MAGDM approach under interval-valued intuitionistic fuzzy environment was represented.
Yue and Jia (2013), included a soft estimating model for MAGDM problems with introducing a collective decision matrix and a practical and forward algorithm to convert a numerical value to an IVIFN for group decision, so all separated decisions on a feature collected according to interval-valued intuitionistic fuzzy number (IVIFN). To be able making decisions under intuitionistic fuzzy atmosphere to demonstrate the developmental approach, was given an example for supplier selection and a sensitivity analysis with different attribute weight the compared with another group decision making method from relevant literature. Decision information (attribute values) and exact numerical values, provided by some DMs were collected and the problem of group-decision making GDM was reduced to a MADM problem using interval-valued intuitionistic fuzzy numbers (IVIFNs) the advantages of this method is that each IVIFN has more information of any collected data. And its rank is easier and there are no restrictions for distribution of data and either not for the index number and size of the samples.

An approach consisted of a multiple criteria group decision-making for the aim of choosing the supplier in the context of gap type -2 fuzzy sets was refined by Keshavarz Ghorabae et al. (2014). In terms of significance and utility degree, this method utilizes a stepwise procedure for ranking and evaluating the alternatives and regarding the positive-ideal and the negative-ideal solutions selects the best solution. Their method presents a way for handling fuzzy multiple criteria group of making decision is basis of interval type -2 fuzzy sets.

2.12. The MULTIMOORA technique

Cebi and Otay (2016) considered supplier examination and order distribution problem and formulate it by a two-stage methodology. They hybrid MCDM with multi objective mathematical model under fuzzy environment. the model assumes multiple criteria and multiple products under quantity discounts offered by multiple suppliers with fuzzy conditions and intend to satisfy demand and average lead-time of multiple items constraints. Fuzzy MULTIMOORA was utilized to gain the best solution and each group of order distributed to elected supplies determined by help of fuzzy goal programming. The augmented max-min model guarantees non-dominated solutions and get a crisp single objective function model from fuzzy multi-objective model. All of results compare with another technique.

2.13. Nominal Group Technique (NGT)

In an attempt Rahiminezhad Galankashi et al. (2015) provide an integrated step to take into account the best and green key accomplishment signify in their framework. To extract the most critical performance measures they provided Nominal Group Technique (NGT). As a substitute for green supplier selection, 10 performance measures have been selected. It is attempted in this paper to, with regard to the characteristics of electrical industries, integrate classic supply chain performance measures with green supply chain performance measures. Utilizing NGT for the purpose of extracting the most important green supplier selection key performance indicators (GSSKPIs), paper’s methodology is both qualitative and quantitative that addresses a FANP to rank indicators. It is a flexible methodology for different managerial decisions concerning the evaluation of suppliers. Study’s main implication is to integrate classic and green key performance indicators for selecting the supplier. Dargi et al. (2015) case study to present a framework to help selecting supplier to an Iranian automotive industry. Choosing critical factors according to the automotive industries is less investigated, so this research has been conducted to systematically provide the aim of supplier selection with a framework that consists of the most critical factors. An NGT has been developed for the purpose of extracting the most critical performance measures from a list. The research has a seven-steps-methodology that is appropriate for supplier selection and FANP as well as weighting the extracted measures and determining their importance level. Ghorbani et al. (2012) developed a two-phased model for the purpose of supplier selection and order distribution. At the beginning, based on the qualitative and quantitative criteria conclusion from SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis suppliers were evaluated. Giving description
the basis, Shannon entropy is then used to compute weight of criteria. Afterwards, these results were utilized as input for integer linear programming (ILP) in order to order suppliers.

Ghorbani et al. (2012) also took into account an assumed case as a numerical example. In order to conduct a SWOT analysis, a matrix has been developed to identify the position of suppliers. With regard to the strengths, weaknesses, opportunities and threats, four areas have been distinguished. Suppliers that are in opportunities-strengths area outperformed and those in the threats-weaknesses were the worst. The proposed model enjoys characteristics and innovations the main of which were: considering the company’s policies, justifying the internal and external factors, providing a model which at exact time accomplishes supplier selection and order allocation, assigning fuzzy deduction to cope with uncertainty of human conception and specifying criteria from strategic standpoint.

<table>
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<td>Literature</td>
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<td>Karsak &amp; Dursun (2016)</td>
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Table 3: Interval valued intuitionistic fuzzy hybrid approaches

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<th>Additional features of decision approaches</th>
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<tr>
<td>You et al. (2015)</td>
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<td>ELECTERE I</td>
<td>Multi-criteria group decision making (MCGDM), Atanassov’s interval-valued intuitionistic fuzzy set (AIVIFS)</td>
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<td>interval type-2 fuzzy sets</td>
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<td>Reddy P. et al. (2016)</td>
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Table 4: Mathematical programming techniques

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<td>Generalized intuitionistic fuzzy soft set (GIFSS), Generalized intuitionistic fuzzy soft relations (GIFSR), Similarity measure, score function</td>
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<td>McMI-GP</td>
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Table 5: Trapezoidal fuzzy hybrid approaches

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<th>Literature</th>
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<th>Additional features of decision approaches</th>
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<td>Liao and Kao (2011)</td>
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<td>Sanayei et al (2010)</td>
<td>VIKOR</td>
<td>(Group) linguistic variables expression</td>
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<tr>
<td>Bashiri and Badri (2011)</td>
<td>LP</td>
<td>(Group) linguistic terms, linguistic variables</td>
</tr>
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<td>Wan and Dong (2015)</td>
<td>LP, GP</td>
<td>trapezoidal intuitionistic fuzzy numbers, lexicographic method</td>
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Table 6: Triangular fuzzy hybrid approaches

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<th>Literature</th>
<th>Core DM techniques</th>
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<tr>
<td>Chen et al. (2006)</td>
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<td>(GROUP) FUZZY SMART</td>
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<td>Mukherjee and Kar (2013)</td>
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<td>Junior et al. (2014)</td>
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<td>SOM, TOPSIS</td>
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<td>Lin (2012)</td>
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<td>Rahiminezhad Galankashi et al. (2015)</td>
<td>FANP, NGT</td>
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3 Conclusion

This paper provides a comprehensive literature review on some of articles published for supplier evaluation in recent years. The evaluated articles collected from 2008 to 2016. We analyzed these articles
based on MCDM methods used to solve the supplier selection problem. We organize the methods in thirteen categories: 1. mathematical programming techniques; 2. the fuzzy AHP technique; 3. the Fuzzy TOPSIS technique; 4. the LINMAP technique; 5. the DEMATEL technique; 6. the VIKOR technique; 7. the ELECTRE technique; 8. the Neural Network (NN) technique; 9. the ANP technique; 10. Green and Sustainable Supply Chain Management (GSSCM); 11. Multi-Criteria Group Decision Making (MCGDM); 12. the MULTIMOORA Technique; 13. Nominal Group Technique (NGT). Based on our analysis, the most used methods in the supplier selection problem include AHP, ANP, TOPSIS, Fuzzy AHP, Fuzzy ANP, and Fuzzy TOPSIS. For future research, the other problem can be reviewed based on MCDM methods.

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