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Analyzing the Process of Supplier Selection Criteria and Methods

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Abstract

Supplier selection is the process by which firms identify, evaluate, and contract with suppliers. The supplier selection process deploys an enormous amount of a firm's financial resources and plays crucial role for the success of any organization. The main objective of supplier selection process is to reduce purchase risk, maximize overall value to the purchaser, and develop closeness and long-term relationships between buyers and suppliers. The literature on supplier selection criteria and methods is full of various analytical approaches. Some researchers have developed hybrid models by combining more than one type of selection methods. The current paper provides an overall picture of research on supply chain management, supplier selection criteria and supplier selection evaluation methods (multi-criteria decision making). A summary of the process of supplier selection can be helpful for companies to have a clear understanding of the concept in order to improve their success and competitiveness. The results show that the application of a structured decision-making technique is vital, especially under the complex conditions that include both qualitative and quantitative criteria.

Keywords: Supply chain management; supplier selection; supplier selection criteria; supplier selection methods, multi-criteria decision making techniques; process of supplier evaluation.

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1. Introduction

Both organizations and their overall performance remarkably influence strong reliable relationships in Business to Business (B2B) environment. There was a high attention to studies about internal and external processes in different types of businesses in recent years, due to the fast development of economy and industries worldwide [1]. Thus, nowadays, we have got much more possibilities and ways of managing and controlling the supply chain and related activities.

In construction projects, the material related activities compose more than half of the total cost and have enormous effects on project schedule [2]. Consequently, an elaborated concept is needed, as the Supply Chain Management (SCM) which maximize customer value and achieve a sustainable competitive advantage. In addition, purchasing decisions become more important with the consequence increasing of the purchasing function. As the supplier selection process plays an important role in purchasing activity since companies have become gradually more dependent on suppliers to supply goods and to deliver services which were formerly provided in-house in order to specialize and concentrate on their competencies [3].

Moreover, the selection process has a significant role in reducing the cost, improves profits and the quality of the products, and firms often misunderstand the supplier selection problem as a single-criterion decision-making problem, considering only cost factors when making decisions [4].

Recently business environment has changed, and competitiveness depends on far more factors than just the activities that occur in an organization. That is why it is vital to pay a special attention to key decisions that can improve a company's results, as how to select suppliers which a successful supplier selection will enhance organizational performance. This paper is going to provide a review on supplier selection criteria and methods and provides an analysis and classification on different multi-criteria decision making techniques' applies for supplier evaluation.

2. 2. Literature Review

2.1. Supply Chain Management

The world economy gained new characteristics and with the advancement of globalization, new possibilities have been raised and covered the most important processes of socio-economic development of the world, helping to accelerate the economic growth and modernization [1]. In the past decades, the concept of supply chain management and strategic sourcing was one of the fastest growing area of management [5]. It started in the 1980's to become a featured management concept [2]. Initially, the emergence of the concept was cited by K. Oliver and M. Weber "Supply Chain Management: Logistics Catches up with Strategy", released in London in 1982 [6]. This new advanced concept contains all the material-related activities of construction projects. Lately, it became a new challenge for construction managers in order to procure right quantities of materials to a construction site on time, and within the pre-defined budget [2]. The goal of supply chain management is to improve supply chain performance on both the supplier and the buyer side. It is also the way of a best and longer relationship between buyers and suppliers with more confidence.

Nowadays, this innovatory idea has become an integral part of the business and is forcing companies to reconsider their purchasing-questions [3]. It is an actual advantage for firms because supply chain management has the power to boost customer service, reduce operating costs and improve the financial standing of the company.

A SCM can notably be different from one business to another one. The difference between the old model of supply chain and today's model is that companies have moved away from slow-moving vertical integration where the flows of products, materials and money moved only in one direction [7]. Today, the market requires fast response and much flexibility in movements across the network and between all the participants. It can be a truly complex, global, multi-layered network, with many different types of business partners.

2.2. Supplier Selection

The supplier selection is one of the most important decision-making issues in supply chain management field. The selecting process is critical for enhancing the company's competitiveness, and requires the assessment of different alternative suppliers based on different criteria [8]. According to Tookey [3], one of the most crucial components in SCM is supplier selection; it is a multiple criteria decision making (MCDM) problem which involves both qualitative and quantitative criteria [2]. A suitable supplier selection would reduce purchasing costs, improve profits, decrease product lead time, grow the customer satisfaction, and strengthen the competitiveness [4]. That is why it has become an essential focus for every purchasing organization [3], but there is no any standard for supplier selection, and it should be applied based on the situation.

Whereas a wrong choice can lead the supply chain to suffer losses, and this would directly affect the performance of the company [4]. In fact, it is always difficult to choose the right supplier for purchasing managers, especially today, that the needs of supplier selection criteria are changing. There are three significant steps, as shown in Figure 1. First, it is the criteria identification, most commonly it is about quality, delivery performance, cost, capability, but the price is no longer the primary factor. In reality, selection of adequate criteria depends on the purchasing situation. Then, second comes the questionnaire survey study which is separated in the analysis of results and the determination of criteria weights. It structured with all main criteria and sub-criteria plus one question for investigation additional supplier selection criteria. After that, the third step is the multi-criteria decision making method implementation which consists of choosing the method to use in order to select the best supplier.

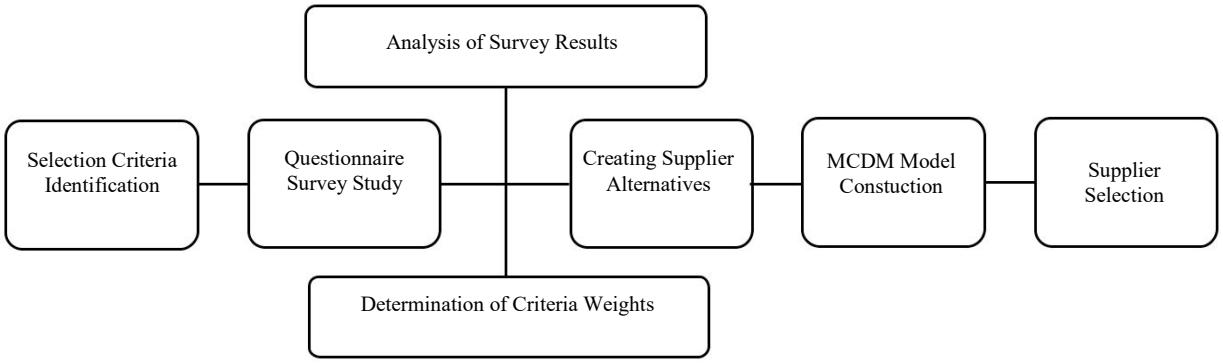

Fig. 1. Supplier selection steps

According to A.E. Cengiza [2], the goal of a good supplier selection is to find the appropriate supplier who can provide the buyer with the right quality products or services at the right price, in the right quantities at the right time. It is difficult to follow the same strategy, while facing different financial status and reputation among its customers even by producing product of same specifications and quality. That is why many firms prefer to pay more money, put more effort and time to ameliorate the purchasing process, valuate in advance suppliers and all possible risks. In addition, in different firms the actual supplier selection can run in a different way [1]. While for some product it can be a simple record of actions where every step of the formal process may not be required, for another product it can change into a highly complex framework where every step is regulated by professionals [9].

2.2.1. Supplier Selection Process

According to [10], supplier selection process is one of the critical organizational activities that is managed by the procurement department. Therefore, the purchasing manager should develop and use an effective process for finding the qualified suppliers to award the business. Handfield [11] mentioned that the process can be an intensive effort requiring a major commitment of resources. Additionally, Weele [12] indicated that the supplier selection process is a part of the purchasing process that is initiated with a market research after defining and specifying the functional or the technical specification. This process contains four steps as described below and shown in Figure 2:

A. Determining the method of subcontracting which the most important thing is to decide on whether to choose a turnkey (performing the whole assignment) or partial subcontracting besides the pricing method before awarding the work.
B. Setting the preliminary qualification of the potential suppliers and drawing up the bidder's list.
C. The preparation of the request for quotation and analysis of the received bids.

The selection of the supplier which is the most important step in the purchasing process and a basis for many other activities. In certain situations, the number of the approved suppliers available is not enough; hence, a thorough supply market research should be conducted for finding new suppliers.

According to Weele [12], when the quotations are received from the potential suppliers, a preliminary technical and commercial evaluation should be done by the purchasing department in order to weight the technical, logistics, quality, financial, and legal aspects. In addition, the offered price can be compared between the suppliers but the more important is to look at the total cost of ownership instead of at the prices itself.

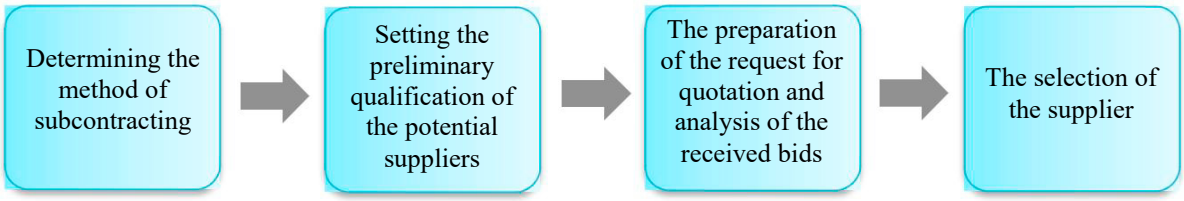

Fig. 2. Supplier selection process [12]

The buyer starts the supplier evaluation process by identifying the "dimensions" it wishes to use when evaluating suppliers. Worapon Thanaraksakul [13] surveyed seventy six papers on supplier selection in the purchasing literature and found that price, quality, and delivery were the most commonly listed supplier evaluation dimensions. Worapon Thanaraksakul [13] provides an extensive list of such dimensions, categorized by prevalence in the purchasing literature. Frequently appearing dimensions include:

- Production capacity and flexibility
- Technical capabilities and support
- Information and communication systems
- Financial status
- Innovation and R&D

Dimensions that appear with moderate frequency in the literature include quality systems, management and organization, personnel training and development, performance history, geological location, reputation and references, packaging and handling ability, amount of past business, warranties and claim policies, procedural compliance, attitude and strategic fit, labor relations record, and desire for business [14]. Of course, buyers often use new dimensions in order to respond to actual's business issues and challenges. Dimensions that have come out recently include environmental and social responsibility, safety awareness, domestic political stability, cultural congruence with the buyer organization, and terrorism risk [14]. On the other hand, Handfield [11] introduced seven steps for supplier evaluation and selection process which are:

A. *Recognizing the need for supplier selection:* the process can be initiated based on the anticipation of a future purchase requirement. Here, the engineering staff might have some preliminary specifications on the type of the needed materials, processes, or services. However, the specifications have no specific details, but these specifications are enough to initiate the process for finding a potential source of supply.
B. *Identifying the key sourcing requirements:* understanding the importance of the requirements that is essential for the purchaser, and these requirements might vary from an item to item.
C. *Determining the sourcing strategy:* that includes for instance, domestic versus foreign suppliers, single versus multiple supply sources, short term versus long term purchase contracts.
D. *Identifying the potential supply sources:* this step is dependent on different sources of information.

E. *Reducing the suppliers' number in selection pool:* purchasing staff often use an in-depth evaluation of all possible suppliers in order to narrow the number to a small list which will be used for an in-depth formal evaluation.
F. *Determining the method of supplier evaluation and selection:* the method will be applied on the remained supplier after the first cut in the former step. The evaluation and selection can be conducted using many methods including evaluating the suppliers' information, using a list of preferred suppliers, or carrying out a site visit.

Selecting the supplier and reaching an agreement: it is the last step of the evaluation and selection process. De Boer [15] offered the supplier selection framework (see Table 1) that accommodates the diversity of situations in the purchasing practices on one axis and the actual steps of purchasing on another. He divided the purchasing process into a matrix that consist of problem definition, formulation of criteria,qualification, and choice on a vertical plane and on horizontal plane, new task, modified rebuy (leverage items), straight rebuy (routine items), and straight rebuy (strategic/bottleneck).

Table 1. Supplier selection framework adapted from De Boer [15]

	New task	***Modified rebuy (leverage items)***	***Straight rebuy (routine items)***	***Straight rebuy (strategic/bottleneck)***
Problem definition	*Use a supplier or not?*	*Use more, fewer or other suppliers?*	*Replacing the current supplier?*	*How to deal with the supplier?*
Formulation of criteria	*Varying importance* *One-off decision* *No historical data on suppliers available* *No previously used criteria available* *Varying importance*	*Moderate/high importance* *Repeating decision* *Historical data on suppliers available* *Previously used criteria available*	*Low/moderate importance* *Repeating decision* *Historical data on suppliers available* *Previously used criteria available*	*High importance* *Repeating decision* *Historical data on suppliers available, yet very few actual selections* *Previously used criteria available*
Qualification	*Small initial set of suppliers* *Sorting rather than raking* *No historical records available*	*Large set of initial suppliers* *Sorting as well as raking* *Historical data available*	*Large set of initial suppliers* *Sorting rather than raking* *Historical data available*	*Very small set of suppliers* *Sorting rather than raking* *Historical data available*
Choice	*Small initial set of suppliers* *Ranking rather than sorting* *Many criteria* *Much interaction* *No historical records available* *Varying importance* *Model used once*	*Small to moderate set of initial suppliers* *Ranking rather than sorting* *Also: how to allocate volume?* *Fewer criteria* *Less interaction* *Historical data available* *Model used again*	*Small to moderate set of initial suppliers* *Ranking rather than sorting* *Fewer criteria* *Less interaction* *Historical data available* *Model used again* *Single sourcing rather than multiple sourcing*	*Very small set of suppliers (often only one)* *Historical data available* *Evaluation rather selection* *Sole sourcing*

2.3. Supplier Selection Criteria

An identification of decision making criteria together with the right supplier selection methods are the driving factors determining a firm's growth and competitiveness, thus criteria are truly important in the supplier selection. For many years, the traditional approach to supplier selection has been to select suppliers simply based on price. However, as companies have learned that the sole emphasis on price as a single criterion for supplier selection is not well-organized, they have turned into to a more comprehensive multi-criteria approach [16].

Recently, these criteria have become increasingly complex as environmental, social, political, and customer satisfaction concerns have been added to previously defined factors such as quality, delivery, cost, and service. The realization that a well-selected set of suppliers can make a strategic difference to a firm's ability to provide continuous improvement in customer satisfaction drives the search for new and better ways to evaluate and select suppliers. The use of multiple suppliers provides more considerable flexibility due to the diversification of the organization's total requirements and fosters competitiveness among alternative suppliers [16]. Despite the strategic importance of the supplier selection, many firms still limit themselves with evaluating the price performance as the single determiner when choosing a supplier. The evaluation of this only criterion is not the most suitable approach,

since many other factors must be considered for the selection process to be successful. Nowadays, it is important to structure the problem and to explicitly assess pertinent criteria before reaching a decision. Several methods have been developed to solve multi-criteria problems, and many of them is the idea that most decision-making can be improved by breaking down the general evaluation of alternatives into evaluations on a number of relevant criteria.

Supplier criteria are divided into quantitative and qualitative attributes. The selection of suitable criteria also depends on the purchasing situation.

Table 2. Supplier selection criteria with their related sources

Criteria	***Authors***	***Definition***
Quality	[13, 17-29]	The ability of the supplier to meet quality specifications consistently which include quality features (material, dimensions, design, durability), variety, production quality (production lines, manufacturing techniques machinery), quality system, and continuous improvement.
Delivery	[13, 17, 18, 21, 26, 29, 30]	The ability of the supplier to meet specified delivery schedules which include lead-time, on-time performance, fill rate, returns management, location, transportation, and incoterms.
Performance history	[13, 31]	The performance history of the supplier in the financial, economic, social, organizational, and societal area.
Warranties and claim policies	[13, 20]	The superiority of the specified written guarantee that promise to repair or replace product if necessary within a specified period and also the claim policy as a formal request for coverage or compensation for a covered loss or policy event.
Production capacity	[13, 17, 20, 32]	The volume of products or services that can be produced by a supplier using current resources.
Price	[13, 17, 18, 20, 30, 31]	The price criteria includes unit price, pricing terms, exchange rates, taxes, and discount.
Technology and capability	[13, 20, 23, 24, 29, 33, 34]	The technological capability of a supplier and ability to acquire new technologies and technical resources for research and development practices and processes.
Cost	[21-23, 25-27, 29]	The cost is a monetary valuation of effort, material, resources, time and utilities consumed, risks incurred, and opportunity forgone in production and delivery of a good or service.
Mutual trust and easy communication	[29, 33, 34]	The level of trust on the quality of the work provided by supplier. And refers to the obligations owed between the buyer and the supplier. The easy communication is a simple exchanging of information between the firm and the supplier.
Communication system	[13, 17]	The communication system of the supplier including information on progress data of orders.
Reputation and position in industry	[13, 17, 31]	A ranking and reputation of a brand, product, or company, in terms of its sales volume relative to the sales volume of its competitors in the same industry.
Supplier's profile	[22-24, 29]	The superiority and reputability of the supplier's status, past performance, finance, certificates, and references.
Management and organisation	[13, 17, 31]	The reputability of the supplier's management team and the efficiency of their decision making to resolve issues in order to be both effective and beneficial.
Repair service	[13, 18, 20]	The ability of the supplier to restore something damaged, faulty, or worn to a good condition.
Attitude	[13, 17]	The attitude of the supplier while you are in contact with them such as politeness and confidence.
Risk factor	[22, 35]	The risk factor is a measurable characteristic or element, a change in which can affect the value of an asset, such as exchange rate, interest rate, and market price.
Commercial plans and structure	[28, 33, 36]	The supplier's format statement of a business goals, reasons they are attainable, and plans and infrastructure for reaching them.
Labour relations record	[13, 17]	The supplier's relationship between management and its workforce.
Geographical location	[13, 17]	The geographical location of the supplier.
Reliability	[13, 18, 26]	The supplier's quality of being trustworthy and dependable based on the references (buyers feedback), financial stability (capital, annual turnover), past and current business partners, company organization and personnel, diversity of ownership, and cultural awareness.
Service	[22, 25, 26, 29]	The ability of supplier to provide intangible products including the customization (size, shape, color, design, OEM, label service), minimum order quantity, communication (respond time, information, language), industry knowledge, flexibility, and response to change.
Process improvement	[17]	The ability of the supplier to identify, analyse, and improve upon existing business processes within its company for optimization and to meet new quotas or standards of quality.
Product development	[13, 18]	The ability of supplier to modify an existing product or its presentation, or formulation of an entirely new product that satisfies a newly defined customer want or market niche.
Environmental and social responsibility	[37]	The supplier's responsibility to use natural resources carefully, minimize damage, and ensure these resources will be available for future generations.
Professionalism	[13, 21]	The supplier's competence or skill expected of a professional.

According to the literature, there are a lot of supplier selection criteria which are gathered and listed in Table 2. Furthermore, the definition of each criteria is provided. Each company should choose the criteria that fits with its expectations about the supplier. Then, with those criteria, they will make a ranking in order to find the best supplier.

2.4. Supplier Selection Methods

There has been an evolution in the role and structure of the purchasing function through the nineties and the supplier selection problem has become one of the most important issues for establishing an effective supply chain system [16]. The high firms' dependency concerning the purchasing process makes supplier selection a strategic process for organizations. The supplier selection depends on various things including multiple methods because there is no standard of this process. Every supplier selection is different, so obviously the firms has a multiple choice of methods based on their product, expectations, criteria, and the industry. In addition, the methods chosen are extremely important to the overall selection process and can have a remarkable influence on the selection results. Thus, it is significant to know which method should be used in different situation. Tahriri [32] presented how preferences of methods for evaluation have changed for years and categorized the existing methods into quantitative and qualitative:

- Quantitative researches are adopted from mathematics, physics, and statistical sciences to evaluate strengths and weaknesses. Quantitative studies involve gathering data in the numerical form to quantify the problem so as it can be categorized, ranked, or measured in units. It tests hypothesis in one reality; statistics is measurable and logical.
- Qualitative methods might include tools for visualizing the perception as well as tools for brainstorming alternative solutions [15]. Qualitative research has an exploratory nature and is used to help in developing clear understanding of a situation. Its objectives are to explore, discover, and describe the reasons and motives. The focus of qualitative method is to examine the depth and breadth of phenomena as well as the importance of nuances associated with the problem. In qualitative research a high level of subjectivity is expected as the researcher is part of process.

Quantitative methods are normally more structured than qualitative ones. Today, both methods are used in integrated models built for supplier selection in comparison to the time before 2003 when quantitative methods were mostly applied [32]. There are several supplier selection methods available which are classified in main categories, and sub-categories. According to Vasina [1], the Cluster Analysis as a prequalification method includes the fuzzy logic. The categorical method contains Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Outranking method with Elimination and Choice Expressing Reality (ELECTREE) and Preference Ranking Organization Method for Enrichment Evaluations (PROMOTHEE), but also the Multi-Attribute Utility Theory (MAUT method). Then, the procedure Activity Based Costing and Total Cost of Ownership are methods based on costs. Besides, according to Om Pal [16], the Linear Progamming, Goal programming and Multi-objective Linear Programming are part of the mathematical programming method, with the Data Envelopment Analysis as a prequalification. Moreover, the Artificial Intelligence technique contains the Case-Based Reasoning and the Artificial Neural Network. With the increasing development of supplier selection, as mentioned earlier, the combined approaches methods have been developed such as Mathematical programming+TCO, AHP + Linear Programming, MAUT + LP, ANP + TOPSIS, or Fuzzy TOPSIS. Figure 3 summarizes the supplier selection methods and their classification.

3. Discussion

In the current global market place, firms need to increase their flexibility to stay competitive and respond to quickly changing markets. Therefore, the practical modeling of supply chain networks is critical for the firms th maintain competitiveness by demonstrating good results in every process both inside and outside of the firm. The purpose of this paper was to intensify the understanding of the role of supplier selection process and its advantages for an organization. The identification and analysis of criteria for the selection and evaluation of suppliers has been the central focus of many academics and practitioners. Research on supplier selection criteria began in early 1960s when it was known as vendor selection [3]. Supplier criteria are divided into quantitative and qualitative attributes,

and the selection of suitable criteria also depends on the purchasing situation. Several authors have pointed out the importance of supplier selection by emphasizing the impact that decisions throughout the entire supply chain have, from procurement of raw materials to delivery of finished products to final customers.

In today's supply chain management, the performance of potential suppliers is evaluated through multiple criteria rather than taking into account only the cost factor. Supplier selection opens unconditionally new perspectives toward better resource allocation, mitigation of risks associated with purchasing and minimizing costs by saving time, money, and effort [1]. But, every supplier selection and evaluation process is very flexible, it leans on the industry and the situation. Due to the fact that there are differences between the companies, there is no single way for purchasing and selecting the supplier. Therefore, positive interactions between the buyer and the supplier in creating long-term relationships are subject to evolving supplier selection criteria [3].

As mentioned before, there is no standard supplier evaluation although there are some decision-making methods which have been developed to help the supplier selection process. Each methods has its own advantages for the firms because they will use the one which fits most with their industry and expectations. Traditionally used methods are considered as appraisal methods by reviewing objective and subjective evaluation criteria [38]. Categorical and weighted point methods are popular due to their simplicity and quicker evaluation process. However, the cost-ratio method has been seen as a complex model and requires a comprehensive cost-accounting system to generate precise cost data [39].

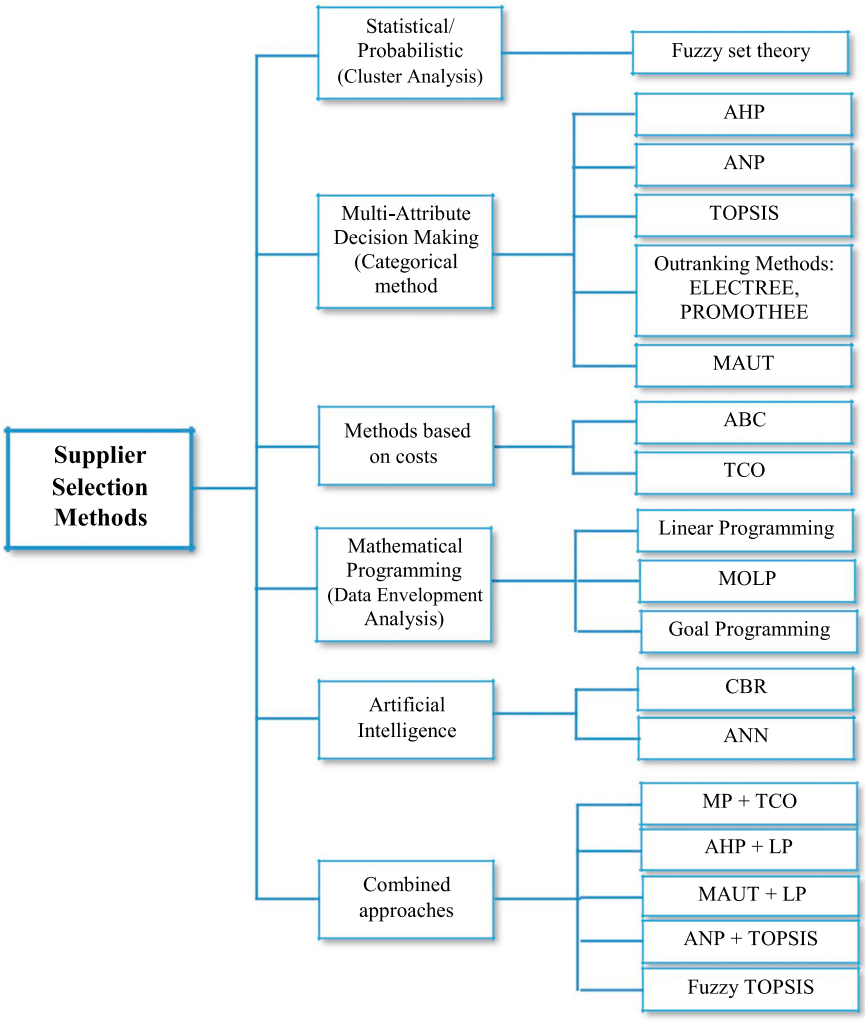

Fig. 3. Classification of the supplier selection methods

Vendor profile analysis is a modified version of the weighted point method employing Monte Carlo simulation to replace ratings based on intuitive judgment [40]. Dimensional analysis was proposed by Willis [41] which allows for combining several criteria of different dimensions and varying importance into a single dimensionless entity. In 1965, Zadeh was the first who proposed the theory of fuzzy logic which is widely applied to situations when decision making under the uncertainty takes place (Vasina). According to Saaty [42], several researchers [43-46] have suggested the use of AHP due to its inbuilt ability to handle both qualitative and quantitative criteria because AHP uses a hierarchy to structure and prioritize multiple criteria into specific clusters and elements and specify levels that usually consist of goal setting, criteria and sub-criteria alternatives [47]. Saaty [47] extended the AHP concept with the Analytic Network Process (ANP) which uses a grid/network structure instead of a hierarchy to decompose the problem (Vasina). Apart from this method, MAUT was introduced by Min [48] in order to handle multiple conflicting criteria existing in international supplier selection, where the environment is more complex and unsafe [49, 50]. Another modified approach is the implementation of the Total Cost of Ownership, which quantifies all costs involved throughout the purchased item's lifecycle [51]. Hwang and Yoon [52], in 1981, developed the concept of the TOPSIS which is based on the principle of finding the optimal solution that should have the shortest distance from the positive ideal and the farthest distance from the negative ideal solution. The Mathematical Programming method is a way of optimizing the selection of several suppliers in order to maximize an objective function based on the constraints faced by suppliers and buyers. The Linear Programming technique has been used to decide on the best supplier according to controlling criteria defined by the purchaser [53]. The goal programming method was developed to perform supplier selection based on the goals required by the client, such as cost, quality, and delivery [54]. Data Envelopment Analysis is used to classify suppliers according to their efficiency levels [55]. Artificial Intelligence is based on computer-aided systems which rely on historical data for decision making. Besides, the Case-Based-Reasoning (CBR) and the Artificial Neural Network (ANN) methods are parts of the Artificial Intelligence models. A CBR System, which still newly discovered, is a software-driven database which provides a decision-maker with useful information and experiences from similar, previous decision situations [56]. The ANN model saves money and time but it demands specialized software and requires qualified personnel who are expert [57]. However, any suitable supplier selection criteria and method to be employed by the purchaser depends on the required capability and their expectation. Thus, based on the purchaser needs and also global market changes, there might be a need to develop new hybrid methods including both quantitative and qualitative aspects for supplier selection and evaluation, this is highlighting the importance of further research in this field.

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