Abstract

The 3PLs (Third Party Logistics) supplier selection problem remains a major challenge in the management of the supply chain and the improvement of the production management of a manufacturing company. This problem is related to the use of a decision support system, in order to organize the operation of the production system, and better manage its various operations.

Recently, the problem of vendor selection is one of the strategic level supply chain design issues. This choice is one of the decisions that have a significant impact on the overall performance of the company. It consists in selecting some suppliers from a set of potential suppliers who will supply the supply chain. Choice decisions are complicated by the fact that various criteria (qualitative and quantitative) must be considered in the choice. In addition, this decision is the subject of a choice of decision makers to allow better coordination between different departments of the company. The analysis and use of such criteria in the context of a group of decision makers has been the subject of research for several years. This paper presents a bibliographical study on the main research works that have dealt with this problem. We conclude with a new initiative solution for the problem of choosing 3PLs suppliers based on FFCA and theory of belief functions.
**Key Words:** 3PLs Providers, Group Decision Support, FFCA, Belief Function Theory.

### I. Introduction

Faced with unstable, increasingly competitive and globalized markets, many companies are finding the limits to optimizing their production systems alone. These companies seek to explore new sources of competitiveness through the optimization of their supply chains and their relationships with their partners. Providing the customer with the desired product and / or service, with better cost, quality and time conditions than those offered by competitors on the market, is nowadays the major concern of every company existing in a local and / or international market [41].

Today, group decision-making processes are of interest to manufacturers because of their ability to respond to market responsiveness. Organizational studies and group process analyzes show the needs of companies constantly in solutions for the organization of their activities around a workspace and the improvement of their competitiveness in a strong competitive context. In this context, the fact of outsourcing a part of the work of one of the services of a company is to call on an external intermediary who realizes the delivery of the activity concerned. The delegated function remains under the control of the company that owns the service, but the function is performed by the partner who undertakes to carry out the work and to respect the principles of the master enterprise. The chosen partner must be competent and trusted because it therefore holds a part of the business activity. This delegation can have significant repercussions for the functioning and the image of the company if the partner does not perform the service well. This is why the outsourcing contract must be precise and specific. The service must be well defined as well as the management of the procedures that this delegation will generate.
Group selection and evaluation of 3PLs suppliers is still the most critical activity in the logistics chain because of the importance of its role and its ease in the operation of the chain. Decisions are complicated by the fact that the various criteria must be considered in the decision-making process. In this context, this attracts a lot of researchers as well as many approaches have been proposed in the literature. Thus, our goal in this paper is to present an in-depth theoretical study on the selection and evaluation of suppliers' group and this based on criteria such as cost, delivery time, service, quality.

Many researchers have studied vendor evaluation criteria and selection methods. The methods recently used are Fuzzy Multi-Objective Linear Programming (FMOLP) [34], the combination of Gray Systems Theory and Uncertainty Theory [31], ANP [8], the hybrid method composed of ELECTRE I and the theory of GRAY as a first step and OWA as the second step [17]. These all above described methods give little insights for supplier selection issue, because supplier selection is highly associated with uncertainties and depends on large amount of domain knowledge where expert's assessment play an important role. Therefore, it is necessary to develop a more effective supplier selection method.

The rest of this paper is organized as follows: A Section II presents basic concepts of our problem. Section III describes a formalization of the problem of decision-making. Section IV presents a bibliographical study on the main research works that have dealt with this problem. We conclude with a section V which describes a comparative study on the main methods and defines a proposal for a method of solving the problem of choice of 3PLs suppliers.

II. Basic Concepts

A. Third Party Logistic

Many definitions have been proposed for 3PL. In this section, a number of them are identified to focus on the key elements of each definition.
A 3PL provider is defined as a special logistics intermediary that provides other companies with some or all of the logistics service, generic transport to design, execute and operate the distribution and logistics system in certain period by the form of the contract [13]. In other cases, 3PL sees itself as a professional logistics company that gets the profit while taking charge of part or all of the logistics in a company's supply chain [25]. Beyond this definition, the 3PL provider may be defined as a company or a private company that provides contract logistics services to a manufacturer, supplier, or primary user of a product or a service. It is called a third party because the logistics provider does not own the products but participates in the supply chain at the points between the manufacturer and the user of a given product [1].

![3PL Cycle](image)

**Fig 1 :3PL Cycle [15].**

**B. Groupe Décision**

[27] has defined group decision-making as a human process and is presumptuous to want to dissect, analyze, and formalize it.

Moreover, the usefulness of team decision-making is not simply a function of the quality of the decision made. Effective team decision-making also requires a commitment to make a decision and for any group decision-making problem can be classified into three dimensions: the completeness of the information provided by the users, the type of input format and the type of output format [9].

**C. FFCA (Fuzzy Formel Concepts Analysis)**
FCA is a data analysis technique based on the ordered lattice theory. It defines formal contexts to represent relationships between objects and attributes in a domain and interprets the corresponding concept lattice. The concept lattice is more informative than traditional treelike conceptual structures as it can also support multiple inheritance. This makes FCA a very suitable technique for conceptual clustering [29]. FFCA is an extension of FCA and integrates the fuzzy logic in the FCA to represent the fuzzy information. It has two categories: the first is called a general approach and the second is called unique facet [32].

D. Belief Function Theory

The theory of belief functions is a generalization of Bayesian theory that takes into account the notions of uncertainty and inaccuracy of information [30]. It represents a more flexible framework for modeling and merging information from different sources for better decision-making. This theory is based on a framework of discernment and a function of mass [32].

III. Formalization of the problem

Let:

- \( S = \{s_1, s_2, ..., s_m\} \) is a set of \( m \) suppliers,
- \( M = \{m_1, m_2, ..., m_n\} \) is a set of \( n \) makers.
- \( C = \{c_1, c_2, ..., c_k\} \) is a set of \( k \) criteria.

Let \( P_{ij}(c_k) \) is the degree of membership of the supplier \( i \) in the decision of the decision-maker \( j \) with regard to the criterion defines, with \( P_{ij} \in [0,1] \).

**Used Approach (U.A)**: It is necessary to use an approach to identify the weights of the criteria with regard to suppliers.

**Used Criteria (U.C)**: The research is made by important criteria to have a decision optimal.

**Used Technique (U.T)**: Indicate to the researcher to adopt techniques to have the definitive decision.
IV. Review of the literature

The problem of choosing 3PL suppliers is one of the strategic decisions that have a significant impact on the company's performance. With the evolutions of the manufacturing systems, this decision becomes more and more critical. Different decision support approaches have been discussed in the literature for group decision making in the problem of choosing 3PLs.
providers that we classify them according to their techniques: Artificial Intelligence (CBR, RBR, ANN..), Methods based on total cost (ABC, TCO...), Mathematical programming models (GP, DEA, QFD...), Linear weighting models (FST, AHP, TOPSIS...) and Overclassing methods (ELECTRE, PROMETHEE).

The use of the AHP method in a fuzzy environment goes back to the work of [23]. The authors show how to compare fuzzy ratios by describing triangular membership functions. In his article, [7] presents an approach based on the fuzzy AHP method by introducing triangular fuzzy numbers for the binary comparison between the criteria. For the first time, it proposes a method for calculating priorities for triangular fuzzy comparison matrices.

[16] presented an approach based on mixed non-linear programming (mono and multi-objective cases) to solve a problem of choice of suppliers. The approach takes into account the limitations of the budgets of the different customers, logistics costs, prices, etc. A numerical example is presented to show the effectiveness of the approach. [19] presented an approach based on the fuzzy AHP method for the problem of selecting the location of entities in a supply chain. Similarly, [4] implemented fuzzy AHP to choose the best manufactured system. Decision makers usually find it more convenient for expressing interval judgments than fixed value judgments due to the fuzzy nature of the comparison process [4]. [22] proposed an approach based on the GP (Goal Programming) method in whole numbers in a fuzzy environment. The authors seek to optimize three main criteria namely: minimize the overall cost, minimize the rejections of requests made and minimize the number of late deliveries. The set is subject to various constraints related to customer requests, supplier capabilities, budgets allocated to suppliers, etc. This formulation is very effective in solving problems in cases where the information is vague and uncertain.

An analysis of an effective approach for 3PL service provider evaluation, focusing on operational efficiency [38]. An intelligent vendor report management system consisting of
customer report management, vendor estimation and product coding systems to select vendors during the new product development process [10]. In another study by [10], CBR's decision support system for the knowledge-based system of choice and vendor evaluation for outsourcing operations. [5] look at a problem of choice of 3PL suppliers at the international level and justify the use of the criterion 'political and economic situation of the country of origin of the candidate supplier'. The authors use the fuzzy AHP method to solve the problem. They justify the choice of the AHP method by its practical and systematic nature for this type of problem. In addition, fuzzy logic is used because of its ability to represent uncertain information. A numerical example is presented to validate the method. To conclude, the authors note that the complexity of the problem is based on the number of criteria and sub-criteria used in an international dimension of the problem. [18] present a state of the art dedicated to the methods used to solve the problem of choice of suppliers. They list all the methods used and read the advantages and disadvantages of each. The authors propose a method based on "Association Rules Mining Algorithms" fuzzy to have more flexibility in the evaluation of suppliers and decision-making. They justify the choice of fuzzy logic by the nature of the information used, which has a qualitative and non-quantitative form. After defining the different criteria, the authors use a database that contains certain information specific to each provider in relation to the selection criteria. On a numerical example, the authors show the effectiveness of the method developed and insist that rules can be exploited via a database to provide decision makers with a more flexible assessment of potential suppliers. [36] deal with a stochastic distribution network design problem where 3PL provider selection, distribution center location and demand area assignment decisions are processed simultaneously. The goal is to solve a complex optimization problem that brings together three levels of decisions: (i) choice of locations of distribution centers, (ii) selection of suppliers to ensure supplies (in one type of product) and finally (iii) assignment of demand areas to localized centers.
[2] deal with a problem of choice of 3PL suppliers from the textile industry. The problem is to choose a number of suppliers from among the potential suppliers, the modes of transport to be used and the storage policy to be adopted by the single distribution center of the chain. They present a simulation-based optimization approach using multicriterion genetic algorithms to solve this problem. [24] proposed a method for selecting suppliers by considering the effects of interdependence, among the selection criteria (price, quality, delivery and technique), as well as achieving optimal order allocation among suppliers choose. The proposed method accordingly incorporates two steps: (i) combination of ANP with fuzzy PP in a more powerful fuzzy ANP (FANP) to select providers, (ii) apply multipurpose linear programming (MOLP) to determine the order assignment among the chosen suppliers. [26] proposed a two-stage dynamic multi-criteria programming approach for the problem of supplier choice and order allocation. In the first phase, the AHP method is used to address the multicriteria decision in the supplier rank. In the second step, the order allocation model is proposed which aims to maximize a service function for the company as well as to minimize all supply chain costs.

[28] used another method of group choice; the VIKOR method was developed to solve multiple criteria of decision-making problems with contradictory and non-commensurable criteria. In the case of his document it is used for the choice of insurance companies by investors in Türkiye. It is applied to determine the best feasible solution according to the chosen criteria

[11] proposed an integer linear programming model to simultaneously determine the timing of supply, lot size, suppliers, and carriers to be chosen in order to incur less all the cost overhead. the planning horizon and they continued their research while proposing another model based on the GP to solve a problem of multiple choice, indeed the intention of the model is to determine the timings (moments), the size of batch to be procured and the supplier and carrier to be selected in each replenishment period.
in his paper, they proposed a method based on fuzzy intuitionistic preference relations (IFPR). Indeed, they defined an interactive group decision-making procedure in which similarity measures between group preference relationships and the fuzzy optimal intuitionist solution are used to rank the alternatives. [20] proposed a group decision-making method based on DEA and QFD. Indeed, this methodology identifies the characteristics that the product purchased should possess to meet the needs of the business and then it intends to establish the relevant vendor evaluation criteria. [40] presented a confusing (blurred) multipurpose programming provider selection model for the supply chain outsourcing risk management.

[22] proposed a new model consisting of two complementary methods: AHP and FGP (Fuzzy GP) to provide the decision support group to identify and classify providers based on the preferences of a group of decision makers. In the consensus. It proposed a hybridization of two methods to solve the problem of choice of suppliers, the first step is based on the fuzzy AHP with the method of geometric means to prioritize and aggregate to the preferences of a group decision makers. The second step, the priorities found in this group were integrated with the GP (multi-objective programming) for the discriminant analysis to provide optimal decision support.

[3] attempted to solve the group decision problem based on the linear programming method with Fuzzy Logic Integration (FLPM) with fuzzy reciprocal preference relations. [38] proposed a method for solving group decision problems in a fuzzy intuitionistic environment based on an extension of the TOPSIS method. The author used this method to evaluate the satisfaction of the masses in a university.

[33] proposed a model based on the TOPSIS Soft method for analysis as part of the multicriteria group decision for renewable energy supply systems in Turkey. [6] presented a new approach, called the HF-ELECTRE II approach, which combines the idea of HFS with the ELECTRE II
method to effectively manipulate different opinions of group members who are frequently produced by dealing with multicriteria decision support problems.

Ultimately, **fig 3** presents the taxonomy of the group selection of supplier’s problem and its related approaches.

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**Fig 3: Group selection of suppliers Taxonomy.**
V. Comparative study

In the previous section, we looked at existing approaches that describe the group decision problem. In this section, we propose a comparison between the methods according to the following criteria.

a) Selection criteria

Generally, the choice of suppliers is a multi-criteria decision that often involves the simultaneous consideration of several criteria such as price, delivery time and quality; and it is extremely difficult to find a supplier who excels everywhere.

In this section, we will present the different criteria that we will use during our study.

For the problem of supplier choice, [12] is the reference for introducing the definitions of relevant criteria in the 1960s. In his study, Dickson ranked 23 criteria according to their importance in selecting suppliers. This ranking is based on a questionnaire sent to the purchasing managers of a number of companies located in the USA and Canada at the time, the four most important criteria were in order: the quality of the product, delivery performance, past supplier performance and warranty policy.

In his article, [14] presents a study of important aspects to consider when choosing suppliers. It describes in detail three main criteria that are the provider's technology status, the vendor's financial status, and the vendor's strategy and organizational culture. For each of these three main criteria, the author identifies several important sub-criteria.

A detailed review is given by [37], covering 74 articles on choice of suppliers. The authors observe that aspects related to price, delivery, quality and 'production capacity' are the criteria most often considered in the literature.
We note that the criteria most used to have a good decision in a company are the delivery time, the quality of the product, the cost and the service.

a) Comparison of methods

<table>
<thead>
<tr>
<th>Methods</th>
<th>Criteria</th>
<th>Technic</th>
<th>Avantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematical programming</td>
<td>Cost, Delivery</td>
<td>GP, DEA, QFD</td>
<td>- Possibility to introduce or not the constraints in the model</td>
<td>- Difficult to analyze the results of the method.</td>
</tr>
<tr>
<td>[20], [22]</td>
<td></td>
<td></td>
<td>- Proposes an optimal solution (mono-objective case) or several solutions (Multi-objective)</td>
<td></td>
</tr>
<tr>
<td>Weighting method</td>
<td>Cost, politics</td>
<td>AHP, FST, FLPM</td>
<td>- Fast and easy to use</td>
<td>- Very complex in case of increase in the number of criteria</td>
</tr>
<tr>
<td>[16],[26],[3]</td>
<td></td>
<td></td>
<td>- takes into account subjective criteria</td>
<td></td>
</tr>
<tr>
<td>Artificial Intelligence [10]</td>
<td>CBR</td>
<td></td>
<td>- Flexible knowledge base</td>
<td>- Feature</td>
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<td></td>
<td></td>
<td></td>
<td>- takes into account qualitative factors.</td>
<td>- Difficult</td>
</tr>
<tr>
<td>Overclassing methods [6], [33]</td>
<td>ELECTRE II, PROMETHE E, VIKOR</td>
<td></td>
<td>- Little information</td>
<td>- Setting</td>
</tr>
</tbody>
</table>

Table 1: Comparative study of different methods
Table 1 presents a four-category classification of the approaches used for decision making in the supplier group selection problem. For each category, the different techniques used to solve the selection problem have been presented under a finite number of important criteria. the main advantages and disadvantages have been cited for the techniques in order to understand their weak and strong points.

Conclusion and Future works

Although the literature aid group decision for the selection problem of suppliers is large enough, the applicability of group decision support theories is yet to be explored extensively to the problem of selecting suppliers. In fact, to the best of our knowledge, none of these studies has attempted to provide support for decision-making group. Our study highlights a hybrid method based method Fuzzy AHP method and FFCA (Fuzzy Formal Concept Analysis) method. Fig 4 shows the model to follow:
In this paper, we treated a review of the literature on key research on the 3PLs providers of group selection problem and the different methods used to solve this problem. We have proposed a hybrid method to solve this problem. Our main future work is to highlight the different steps that make up the group decision-making process for supplier selection and to propose a real-time prediction technique to optimize the final choice.

Fig 4: the proposed model of group decision
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