MULTICRITERIA DECISION MAKING FOR THE SELECTION OF AGRI-FOOD SERVICE PROVIDERS

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The agriculture sector in Morocco has become a necessity, given the intensification of global competition and the openness of markets to new regulations and requirements. In this regard, we want to put forward the guidelines for the successful agricultural outsourcing strategy in Morocco. The existence of high-performance and potential stakeholders called Agriculture Service Providers (ASP) to meet the specific contractors' demands is crucial to the strategy's success. Due to the multitude of MultiCriteria Decision Making Methods (MCDM), decision makers are faced with the challenge of selecting the most appropriate MCDM method, as each of these methods has its own limitations, specifities, and can yield different results when applied to a different problem. The study carried out is a comparative approach between a variety of multi-criteria decision making methods (MCDM) :AHP, TOPSIS, VIKOR and PROMETHEE II using fuzzy logic. A MCDM selection process aims to highlight the advantages and limitations of each method for evaluating the quality of the solution generated. We accomplished this by using assessing's indicators. Finally, a sensitivity study was conducted to examine the robustness.

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1 Introduction

Agriculture is a very strategic sector at the national level. Its importance is evaluated by its direct impact on the economy's competitiveness (Arif, 2016).

Many previously integrated company functions have been gradually moved to third parties. Today, outsourcing is booming and affecting the support functions of the value chain, notably agricultures (Quélin, 2003). To remain competitive in the face of trade globalization and increased competition, companies must collaborate closely with external partners (Colin, 2005).

This collaboration requires coordination in the supply chain between Agricultures Service Providers (ASP) and their clients (Contractors) (Aguezzoul, 2019). It is strategic since, in most industries, 60% to 80% of their added value refers to suppliers (Pinedo, 2008).

However, to set up and succeed in this inter-organizational collaboration, the purchasing firm (Contractor) must select a group of performant partners of ASP who must meet its profit and risk reduction requirements (Aguezzoul, 2019).

Many manufacturing and service industries use the decision-making process, which entails affecting resources to the appropriate activities and attempting to optimize one or more objectives (Calvi et al., 2010). In this context, there are three hierarchical levels of decision making: strategic, tactical, and operational, which are differentiated by the horizon time and the level of responsibility.

As a result, selecting an ASP becomes a strategic decision with major impacts for a company's overall performance (Saharidis et al., 2006). However, the repercussions of these decisions might be difficult to undo.

These types of decision problem are handled by different methods such as statistical methods, artificial intelligence, multi-criteria decision methods, mathematical programming, hybrid methods and many others.

In this aim, we will present Multi-Criteria Decision-Making Methods (MCDM) used to solve the problem of provider selection (Efe, 2016). These methods are based on a set of criteria, often conflicting, that are evaluated to come up with the best solution or alternative. So, their objective is to model the inference decision maker's as precisely as possible.

The goal of this sort of decision issue is to assign the best ASP to assist with the agricultures outsourcing in Morocco context, having regard to the nature of the activity and the contractor's potential.

In this study, a specific attention has been paid to some MCDM methods such AHP, TOPSIS, VIKOR and PROMETHEE. It has been aimed to examine the existing literature as well as their application domains.

Therefore, our approach is based on a comparative study between the various MCDM methods as well as a sensitivity analysis of the alternatives obtained. This study will bring the answer to our research question (RQ): what is the appropriate MCDM for selecting the most suitable ASP for the agricultures outsourcing process?

This approach will serve as a benefical road map for contractors who want to outsource their agricultural services.

This is an original piece of work based on data concerning ASP operating in Morocco, and it is a continuation of the previous work on the importance and benefits of the outsourcing strategy as well as the ASP selection criteria.

The rest of this paper has been structured as follows. The decision-making methods have been explained in detail in Section 2 and reaffirmed with a literature review, particulary the selection of ASP. It is worth noting that, according to this study, the area of applicability of these methods is rich in terms of problems similar to the ones we are looking at. In Section 3, the presentation of data and the approach used to apply the different MCDM have been introduced. The treatment and findings resulting from the comparison between the different methods, which is followed by the selection of the most suited method, has been discussed in Section 4. In Section 5, we will examine the results' robustness by doing a sensitivity analysis. The paper has been concluded with findings and future perspectives in Section 6.

2 Literature Review

The success of the outsourcing of the agriculture services, which has been recognized as a source of competitiveness, is a windfall for shippers who are seeing their agricultural performance improve (Hartmann & De Grahl, 2012). This has impelled contractors to increase their recourse of outsourced agricultures services (Kacioui-Maurin, 2016).

ASP is becoming increasingly important in the execution of agricultural operations (Roveillo et al., 2012). To succeed in this role, they must vary their offerings, spanning from the conduct of agricultures operations to supply chain management (Jharkharia & Shankar, 2005; Fabbe-Costes et al., 2009). The evaluation and selection of suppliers has an impact on almost every decision in supply chain management (Ghadimi et al., 2017).

The decision support system is a crucial component of appropriate decision-making in a complex environment (Sarabi & Darestani, 2021). Therefore, a suitable ASP must offer a combination of reliability, performance, agility, and productivity, to maintain a greater degree of competitiveness (Chen et al., 2018). The challenge of selecting a supplier is a decision issue, according to (Shinkman, 2000).

In the literature, several authors have examined supplier selection and evaluation issues, focusing on supplier evaluation criteria as well as the multidimensional aspect of the problem (Ben Jeddou & Kalboussi, 2015). A different view of the relationship between manufacturers and ASP is proposed by (Hiesse, 2009). The company must, therefore, select a number of providers considered to be suitable partners. This decision might be based on a variety of factors, including strategic, technological, and regional aspects (Kierzkowski, 2005).

2.1 Multi-criteria decision-support

Multi-Criteria Decision Making MCDM is a sub-domain of decision support (ROY, 1985), in which many alternatives are evaluated through several criteria. In these decision-making problems, using a single criterion doesn't allow for efficient distinction of alternatives while considering all of the decision-preferences.

MCDM is an analysis that aims to spell out a coherent family of criteria to understand the different consequences of an alternative (Maystre et al., 1994). In addition, (Vincke, 1992) states that multi-criteria decision-making aims to provide a decision-maker with tools to make headway in solving a decision issue including many, often opposing points of view.

Multicriteria analysis methods or, more precisely, MCDM are fairly recent tools that are in full development (Ben Mena, 2000).

There is a large number of MCDM. In this regard, we distinguish between two schools that follow quite distinct basic concepts.

The first is the "American School", which frequently employs an additive utility function that combines utility values to get a global score for action. The simplest method in this category is the weighted sum method. Multi-Attribute Utility Theory (MAUT), Multicriteria Hierarchization Method (MHM) (Saaty, 1984), or AHP for Analytical Hierarchy Process are examples of this sort of category (FRÄMLING, 1996).

The European school generally favors the application of methods based on the concept of over-ranking between potential actions. The concept of over-ranking emanates from the fact that one element is preferred above another from one or more points of view. The most well-known methods include: ELECTRE (Elimination Et Choice Translating Reality) (Roy, 1968, 1978) and PROMETHEE (Preference Ranking Organisation METHod for Enrichment Evaluations) (Brans et al., 1984).

The main ASP selection models were classified into five categories by (Aguezzoul, 2014):

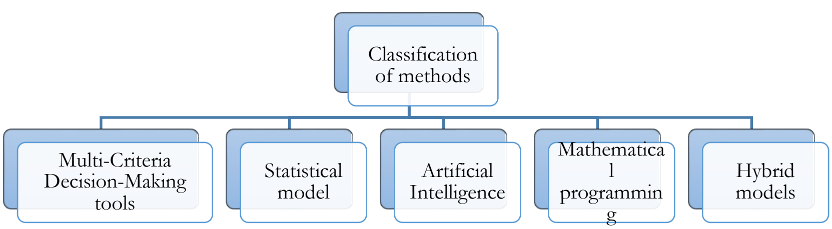

Figure: 1 Classification of methods

Source: own.

The kind of criterion (qualitative or quantitative), the outsourced activity, and the set of an ASP in the competition all influence which model is used.

BOEING has tackled the issue of supplier selection by using DEAHP (Data Envelopment Analytic Hierarchy) method, which combines the DEA and AHP method (Zouggari, 2011).

(Chan & Kumar, 2007) are interested in supplier selection challenges at the international level, using the fuzzy AHP method to solve the problem.

The choice of the AHP method is justified by its practical and systematic nature for this sort (of issue) of problem, whereas the fuzzy logic was chosen because of its ability to represent uncertain data (Zouggari, 2011).

The AHP method is utilized particularly to process the multi-criteria decision problem for supplier classification when it concerns the supplier selection (Zouggari, 2011).

The problem of supplier selection has been adressed by (Lin, 2009), considering the effects of the interdependence between the choice criteria. The method used entails combining the ANP method, which is a mutation of AHP, with mathematical programming in fuzzy numbers.

In the telecommunication field, (Onüt et al., 2009) proposed an approach for a supplier choice problem, this approach combines the fuzzy ANP method and the fuzzy TOPSIS method. In order to assess the relationship between the originator and the supplier, (Lee, 2008) proposed the fuzzy PAA approach to supplier selection.

Likewise, (Guneri et al., 2009) proposed an approach based on a combination of the fuzzy TOPSIS method with linear programming to process the problem.

A supply chain study was conducted by (Shaw, 2012) to select the best supplier. The AHP approach, which is used to examine the weights of several components, was utilized in this situation (Kierzkowski, 2005).

Some approaches involve other methods in a fuzzy environment such as AHP, ANP, DEA, TOPSIS, CBR, P-SVM, GP, MP, and MOMILP (Zouggari, 2011).

(Jayant et al., 2014) have evaluated the 3PL type ASP which can effectively ensure that companies reverse agricultures operations. The purpose of this research is to choose and evaluate several 3PL type ASP for reverse agricultures. They use AHP as technical of analytical hierarchical process and the order of preference by similarity with the ideal solution (TOPSIS).

In the same context, (Akkaya et al., 2015) used the fuzzy AHP approach to assess criteria for the selection of the best provider.

(Yazdani et al., 2016) evaluated the selection concept and the relevance of strategic decision-making in order to minimize operational costs and increase organizational competitiveness for the development of trade opportunities.

(Ebrahimnejad et al., 2012) proposed a decision-making model taking into the account the VIKOR's imprecision for categorizing projects based on their performance.

To solve the supplier selection problem, (Bai & Sarkis, 2018) coupled the theory of Neighbourhood Gross Set (NR) with VIKOR or TOPSIS decision-making techniques, in order to evaluate and classify decision-making techniques including hybridization between TOPSSIS and VIKOR.

(Mutikanga et al., 2011) used the PROMETHEE multi-criteria method to solve the complex water management and the problems of the strategic planning of this management, while taking into consideration decision-makers' preferences and the uncertainty that the problem generates.

(Behzadian et al., 2010) proposed a literature review on the PROMETHEE method's applications, stating that it is a good way to address the issue of supplier choice.

Several models have been presented in the literature for the Multi-Criteria Classification (MCC) (Ben Jeddou & Kalboussi, 2015) that might be used to classify ASP. In the following section, we will focus on the AHP (Analytic Hierarchy Process), TOPSIS, VIKOR and PROMETHEE II methods.

3 Methodology

3.1 Presentation of the approach used

The multi-criteria or multidimensional nature of the problem of choosing ASP makes the problem more complicated, hence we presented MCDM for selecting ASP as part of an outsourcing strategy.

The assessment of ASP will be the emphasis of our strategy which will use a multi-criteria classification technique to prioritize 57 ASP based on five evaluation criteria.

Several papers on the selection problem have suggested a multitude of criteria and utilized various approaches to evaluate them (Aguezzoul, 2014; Chai et al., 2013; Ho et al., 2010).

To do so, we will conduct an exploratory study of a representative sample of ASP operating in Morocco which will include both international ASPs with Moroccan subsidiaries and local ASP company.

As mentioned, 57 ASP were used in this exploratory, quantitative, and qualitative study. It will allow us to get a statistically representative sample of TOP ASP, whether, in terms of technological innovation, service range, or level of traceability employed ..., these ASP selection features will lead us to the formulation of the research criteria.

The study will be based on the following elements:

- Secondary data of ASP operating in Morocco, gathered via their portal or website.
- ASP's approaches for outsourcing agriculture services.
- Synthesizing table summarizing all of the data collected.

On the basis of this information, we will develop a comparative study of the four multi-criteria decision-making methods that we will pick for the ASP selection problem by using multidimensional statistical tools to link all of the ASP and the selection criteria by contractors as examples:

- Dynamic cross-tabulations.
- Correlation test.
- Method sensitivity analysis.
- Charts.
- Dashboard.

The exploratory study's findings will provide the most suitable methods getting relevant results as well as the best selections from all available alternatives, also the similarities between these methods, their intersections, weaknesses and strengths.
In this section, the methodology used as well as a sample of Moroccan ASP will be presented in order to identify the ASP that best meets the contractor's needs from a large pool of available ASP on the market (Fig. 2).

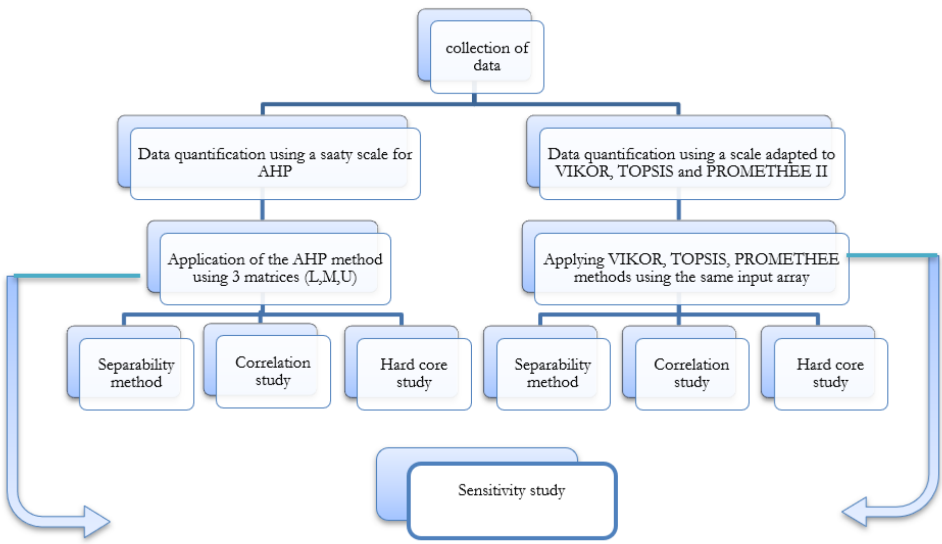

Figure 2: Methodology used

Source: own.

The domain in which we are interested, namely agricultures service provider management, is a promising sector for multi-criteria methods.

We will focus on the following methods: AHP, TOPSIS, PROMETHEE II, and VIKOR, thus we will adopt the fuzzy logic concept to make use of the ASP rating's fuzzy or uncertain nature, as well as the weights attributed to the criteria.

3.2 Decision Making Process

The selection of ASP is one of the strategic decisions that has a considerable impact on the company's performance. The ASP choice challenge for the decision-maker is determining the number of ASP and the ASP portfolio to be kept (Zouggari, 2011). Therefore, our initial task is to collect the essential information using 57 Moroccan ASP sample presented previously (Azzouz et al., 2020a, 2020b). We have created a table that reports all of this data while making the adjustments for the ease of their use.

The statistical study presented in Table 1 gives us a sense of the Moroccan market's physiognomy in terms of ASP services.

We devised a grading system connected with each criterion in terms of its level in order to quantify and assess the data collected.

Table 1: Scores of the different criteria

	Traceability	Agriculture Prividers (AP)	Technology	Services	Transport
1	Site+contact	AP1	Site	Transport	Basic: road, rail
2	Tracking	AP2	IS/EDI	Warehousing, storage, Handling	Maritime
3	Tracking (customer area, blog,...)	AP3	TMS,WMS,…	Cold warehousing, Temperature controlled storage, handling	Air
4	Advanced tracking	AP4	Software, platform,..	Transit	Courier, Express, urgent transport
5	RFID/GPS ….	AP5	AI,RFID,…	Contract agriculture, advanced	Cold transport, Controlled temperature

The transition from one level to the next is cumulative, the maximum score that can be reached is 5 if all of the criterion's underlying levels are met.

We notice that the types of variables are not numeric types, thus in order to manipulate them, we must convert the so-called linguistic variables to numeric variables by assigning quantifications to each linguistic variable on a scale.

This leads us to introduce the fuzzy concept and linguistic variables to deal with the weaknesses of the methods and their uncertainties.

Indeed, the fuzzy sets proposed by (Zadeh, 1965) give a new mathematical tool for dealing with information uncertainty. Because of the real decision-making situations and the imprecision of human thought, it is hard to convey personal preferences and judgments with confidence.

These judgments are frequently the consequence of a lack of knowledge and/or a difficult quantifiable nature. So, the fuzzy set theory can be used successfully (Zadeh, 1965).

Therefore, a fuzzy approximate value can be used to better model human judgment more accurately. Using a supplier'evaluation as an example, adjectives such as bad, medium, good, and outstanding might be assigned instead of standard numerical values (Igoulalene, 2014).

We will define the fuzzy set to understand it better. Assume X is an ordinary set. A fuzzy set of X is defined by its membership function .

$$: \qquad X \rightarrow [0, 1]$$

$$x \qquad (x) \in [0, 1]$$

The degree of membership of x in X is represented by the value of (x) (Igoulalene, 2014).

These fuzzy numbers also subjected to mathematical operations like multiplication, summation…

The triangular fuzzy number is the most common of the several types of fuzzy numbers. The triangular fuzzy number's membership function is graphically represented as a triangle, with [L; U] as the traingle's base and the point (M; 1) as the lone vertex. As a result, the triangular fuzzy number A will be defined by the real numbers L, M, and U: (L; M; U) (Barros et al., 2017).

3.3 The input data

We utilized two types of input arrays: one of these arrays will be associated with the TOPSIS, VIKOR, and PROMETHEE methods, and the other will be connected with the AHP method since its treatment way differs from the other and each of these tables has a different scale.

Table 2 presents the fuzzy values associated with the following methods: fuzzy TOPSIS, fuzzy PROMETHEE II and fuzzy VIKOR on an appropriate scale.

Table 2: Fuzzy value considered

	Level	L	M	U
Very bad	1	1	1	3
Bad	2	1	3	5
Mean	3	3	5	7
High	4	5	7	9
Very high	5	7	9	9

Following the presentation of the input data for the three methods, we will now present the table of the fuzzy AHP. However, the functioning principle of fuzzy AHP is to cross over the alternatives that are the topic of the study using a square matrix that contains the in-line and column alternatives.

In fact, (Chang, 1996) proposed a method of calculating priorities for triangular fuzzy comparison matrices by introducing triangular fuzzy numbers for binary comparison between the criteria.

So, we will have three matrices for each criterion: the first is the matrix M, which corresponds to the middle values of triplet (L, M, U) elements, the other two matrices are L and U, which correspond to the other components of the triangular fuzzy number.

We partition the triplet (L, M, U) into three matrices to make it easier to calculate, using the Excel tool.

This method generates a large amount of data, calculation and huge matrices. Consequently, we will give just a portion of the matrix M, L, and U in tables A-2, A-3 and in Appendix A that will contain some ASP and is related with only one criterion, in our instance, traceability.

For the fuzzy AHP method, we use a saaty scale that is adapted to our situation. In fact, the difference between the notes varies for two alternatives between 0 and 4.

Score zero is obtained if it is the crossing of the same alternative or if two alternatives have the same note, and 4 if one of the alternatives had a maximum note and the other has a minimum note.

In this respect, we applied a mathematical formula revealed after observing the behavior of the notes on the saaty scale.

Table 3: Saaty scale (Bellaaj, 2011)

The difference in scores	The assigned scores	Verbal judgement & Numerical evaluation		
1	3	Extremely more important 9	8	9
2	5	Very strongly more important 7	6	7
3	7	Strongly more important 5	4	5
4	8	Moderately more important 3	2	3
5	9	Equal importance 1	1	1

4 Results

After applying these four methods, we have reached the following results. We implemented a dashboard that connects all of the worksheets corresponding to the various methods on the one hand, and the different selected sectors on the other hand, which we have fixed to three sectors: transport, large retailers, and agro-food.

The choice of these sectors is related to their vitality and specialization, whether in terms of services or transportation modalities, while recognizing the indisputable role of technology and traceability in assuring a high level of performance in these sectors.

The decision-makers will then have the option of adding other sectors or adapting them to their own needs.

Any modifications to this dashboard will affect the other worksheets as well.

Table 4 shows the fuzzy scores constituting the weights for each sector based on the appreciation of a decision-maker or a group of decision-makers who are trying to reach an agreement between them to evaluate the weight of each criterion considering the nature of its professional activities and the services to be outsourced.

Table 4: Dashboard extract for fuzzy scores

	Dashboard to compare the results Of Fuzzy AHP Fuzzy TOPSIS Fuzzy PROMETHEE FUZZY VIKOR									
		Transport			Agri-Food industry			Large Retailers		
	Designation	L	M	U	L	M	U	L	M	U
Criterion 1	AP TYPE	1	1	3	7	9	9	1	1	3
Criterion 2	Treacability	3	5	7	1	3	5	1	3	5
Criterion 3	Technology	5	7	9	3	5	7	3	5	7
Criterion 4	Services	7	9	9	5	7	9	5	7	9
Criterion 5	Transport	7	9	9	7	9	9	7	9	9

Table 5 contains the ASP classification for the fuzzy AHP method, so we have specified the occurrences of each classification, for example, in our case, we find two ASP for the first classification, one ASP for the second-ranking and a single ASP for both sectors: transport and agri-food for the third-ranking, which corresponds to the fourth occurrence.

We noticed that the two ASP "Géodis and XPO agricultures" share the first position for the three sectors.

4.1 Study of separability between methods

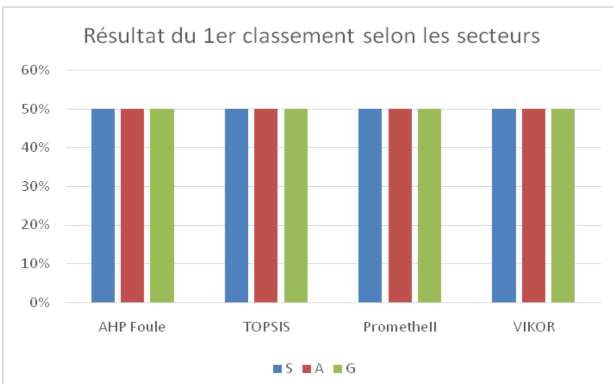

Figure 3: Separability graph of the 1st classification
Source: own.

Table 5: Separability study

Choice quality 1	Transport	Food Industry	Large retailers
Fuzzy AHP	50%	50%	50%
TOPSIS	50%	50%	50%
PROMETHEE	50%	50%	50%
VIKOR	50%	50%	50%

From synthetic dashboard table 6, we will utilize three indicators to assess the classification quality of the alternative ASP.

One of these indicators is the rate of "separability" (Table 5) between the classification levels, which is equal to 1/(number of the level class i), with « i » is the classification order as a percentage. In our case, we noticed that this indicator is equal to 50% for the four methods and for the three sectors giving a one in two chance for the two alternatives. Therefore, we conclude that these methods give a moderately significant precision since they give for each classification two possibilities, they are partially deterministic and account for small differences between the ASP. As a result, the three methods perform similarly for the 1st ranking and they have a consensus on this ranking.

Table 6: General dashboard for the comparison of methods, Result of 2nd choice

			Transport		Food industry		Large retailers	
Fuzzy AHP		1	Bansard Maroc	33%	Bansard Maroc	33%	Bansard Maroc	33%
		2						
		3						
		4						
		5						
TOPSIS		1	Bansard Maroc	33%	Bansard Maroc	33%	Bansard Maroc	33%
		2						
		3						
		4						
		5						
PROMETHEE		1	Bansard Maroc	33%	Bansard Maroc	33%	Bansard Maroc	33%
		2						
		3						
		4						
		5						

			Transport		Food industry		Large retailers	
VIKOR		1	Bansard Maroc	33%	Bansard Maroc	33%	Gefco	25%
		2					OPDR Maroc	25%
		3						
		4						
		5						

Table 7: Separability study of 2nd choice

Choice quality 2	Transport	Food Industry	Large retailers
Fuzzy AHP	33%	33%	33%
TOPSIS	33%	33%	33%
PROMETHEE	33%	33%	33%
VIKOR	33%	33%	25%

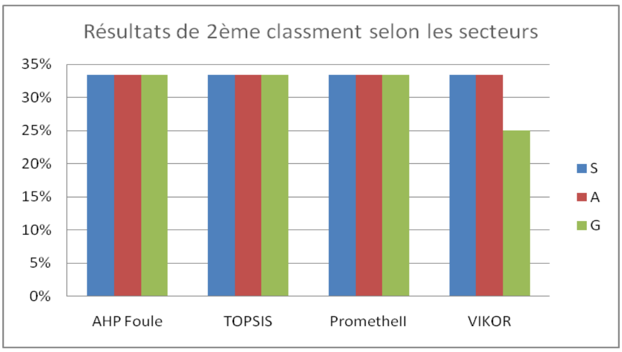

Figure 4: Separability graph of 2nd choice
Source: own.

For the separability index for fuzzy AHP, fuzzy PROMETHEEII and fuzzy TOPSIS is equal to 33% for all three sectors, as the second position is bonded absolutely by the foregoing, so the ASP actually in the second position are associated with rankings 3 since the ranking is shared between two ASP, the second choice is more precise because it corresponds to a single ASP, which is « BANSARD MAROC» as a ranking result for the three methods and the three sectors.

In the two sectors of Transport and agri-food, fuzzy VIKOR acts like the other methods, giving a separability index of 33% and keeping the same ASP that the other methods have chosen in the second position which is «BANSARD Maroc», but for the large-scale distribution sector, fuzzy VIKOR gives rise to two ASP in the second position, "GEFCO" and "OPDR MAROC", both of which offer the same level of service and both of which are more powerful in terms of the type of PL than BANSARD on the one hand, and on the other hand, the decision-maker gives this criterion a moderately significant weighting for the large-scale distribution sector. Regarding separability index, large-scale distribution has an index less than other methods reaching 25%.

Table 8: General dashboard of the comparaison of methods, Result of 3rd choice

		Transport		Food industry		Large retailers	
Fuzzy AHP	1	DHL	25%	DHL	25%	GEFCO	20%
	2					OPDR MAROC	20%
	3						
	4						
	5						
TOPSIS	1	BOLLORE LOGISTICS	25%	BOLLORE LOGISTICS	25%	BOLLORE LOGISTICS	25%
	2						
	3						
	4						
	5						
PROMETHEE	1	BOLLORE LOGISTICS	25%	BOLLORE LOGISTICS	25%	BOLLORE LOGISTICS	25%%
	2						
	3						
	4						
	5						
VIKOR	1	BOLLORE LOGISTICS	25%	BOLLORE LOGISTICS	25%	BOLLORE LOGISTICS	20%
	2						
	3						
	4						
	5						

Table 9: Separability study of 3rd choice

Choice quality 2	Transport	Food Industry	Large retailers
Fuzzy AHP	25%	25%	20%
TOPSIS	25%	25%	25%
PROMETHEE	25%	25%	25%
VIKOR	25%	25%	20%

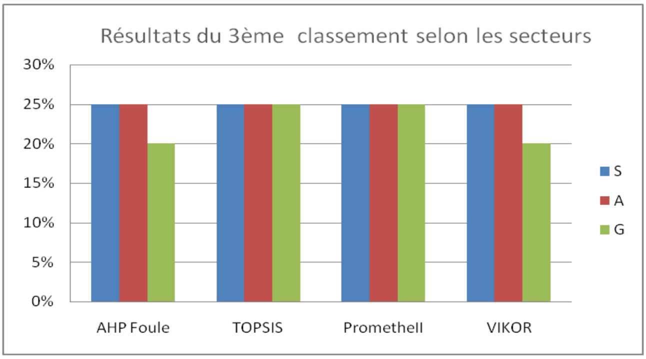

Figure 5: Separability graph of 3rd choic

Source: own.

The separability index is equal to 25% and well represented for the four methods at the Transport and agri-food sector level, especially since this index is dependent on the previous rankings. Furthemore, PROMETHEE II fuzzy and TOPSIS fuzzy maintain this same index value in the third sector, in contrast, the other methods such as fuzzy AHP and fuzzy VIKOR give a separability index of 20%. It is, therefore, less precise for these two methods in the choice of ASP in the large scale distribution; this is due to the previous classification of VIKOR generating two ASP, and the current classification of the fuzzy AHP also gave rise to two ASP.

In addition, regarding the ranking, there is a total unanimity between fuzzy VIKOR, fuzzy PROMETHEE II, and fuzzy TOPSIS on BOLOREE for the three sectors, however, fuzzy AHP, in its classification of ASP, yielded ASP that was completely different from other methods.

In summary, for the three ranks and three sectors, the fuzzy PROMETHHEE II separability index and the fuzzy TOPSIS separability index outperformed the other methods.

As a consequence, we have a broad view of the procedure that provides greater precision and accounts for minor variances in the computation, making it sensitive to slight fluctuations.

The ideal separability for successive choices is to have 100% for the first choice, 50% for the second choice, 33% for the third choice, and 25% for the 4th choice, and so on, this is reflected in the presence of a single ASP for each classification.

Also, PROMETHEE II and fuzzy TOPSIS have a remarkable agreement, in contrast to other methods, where there is a considerable intersection between fuzzy PROMETHEE II and fuzzy TOPSIS.

4.2 Study of the correlation between methods

After examining the separability index, we present the study of the correlation of the rectified order with the average of the rankings. We have introduced the concept of the SPERMAN rank correlation coefficient which aims to make an adjustment to the rankings obtained previously.

We will give correlation tables for the Transport sector only, and the results for the other sectors will be reported.

The SPERMAN rank correlation coefficient formula is

$$=1-$$

Given D, the difference between two ranks related to two methods and N is the sample size studied.

The method consists in classifying the values that allowed each method to classify the ASP, we add the classification based on a comparison conducted between the first position of each variable and the descending classification, with the purpose of calculating the value of D.

We also conducted another correlation study in order to make a comparaison.

Table 10: Calculation with the coefficient correlation function

	Correlation				
	Fuzzy AHP	**Fuzzy TOPSIS**	**Fuzzy PROMETHEE**	**Fuzzy VIKOR**	**Min**
Fuzzy AHP	1	0,954	0,951	0,911	0,977
Fuzzy TOPSIS	0,954	1	0,998	0,981	0,984
Fuzzy PROMETHEE	0,951	0,998	1	0,974	0,982
Fuzzy VIKOR	0,911	0,981	0,974	1	0,960
Min	0,97	0,984	0,9815	0,9604	1

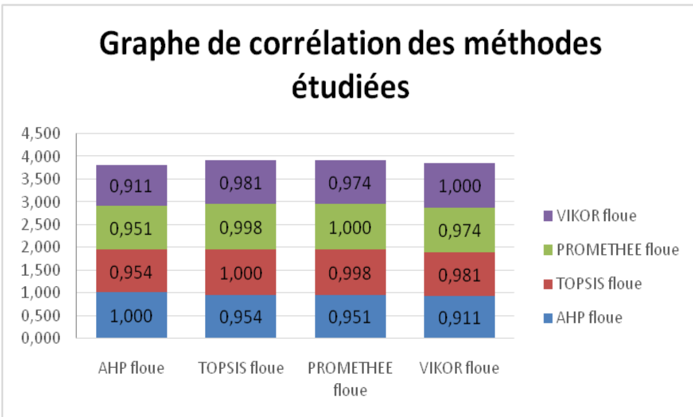

Figure 6: Correlation of methods studied

Source: own.

Table 11: SPEARMAN correlation

	SPEARMAN CORRELATION			
	Fuzzy AHP	**Fuzzy TOPSIS**	**Fuzzy PROMETHEE**	**Fuzzy VIKOR**
Fuzzy AHP	1	0,954	0,951	0,912
Fuzzy TOPSIS	0,954	1	0,998	0,981
Fuzzy PROMETHEE	0,951	0,998	1	0,974
Fuzzy VIKOR	0,912	0,981	0,974	1

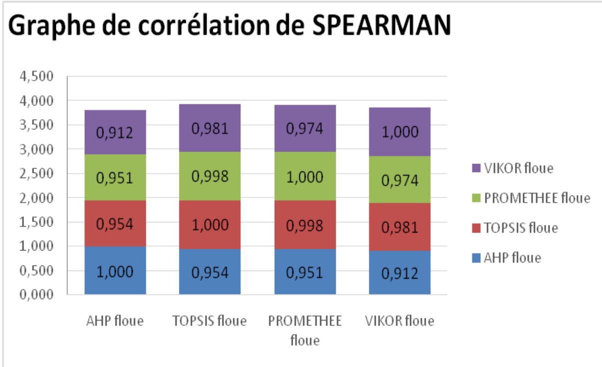

Figure 7: SPERMAN correlation

Source: own.

Table 12: Calculation with formula: 1-6*sum (/(N-1))

	Calcul ation of D squared			
	Fuzzy AHP	Fuzzy TOPSIS	Fuzzy PROMETHEE	Fuzzy VIKOR
Fuzzy AHP	0	1211,5	1273	2309,5
Fuzzy TOPSIS	1211,5	0	63	498,5
Fuzzy PROMETHEE	1273	63	0	674,5
Fuzzy VIKOR	2309,5	498,5	674,5	0

According to the correlation study carried out between the methods studied two by two, it turns out that there is a positive correlation that is quite significant, whether it is the simple correlation or correlation of SPREAMAN. So, there is a variation in the same direction between the methods, but the intensity of the fluctuations and the similarity of the methods varies.

For the correlation table 10, we inserted a minimum ranking for all the ASP by comparing the 4 methods, then we studied the correlation between the different methods and this minimal ranking, it turns out that TOPSIS fuzzy provides better rankings, with a maximal correlation coefficient of 0,985, followed by PROMETHEE II fuzzy with a value of 0,982. At the level of this same table, the methods best correlated between them two by two are PROMETHEE II fuzzy and TOPSIS fuzzy with a value of 0.998 on the one hand, and TOPSIS fuzzy and VIKOR fuzzy on the other hand, with a value of 0.981.

SPERMAN's correlation (Table 12) yields the same results as the other correlations, with a minor fluctuation and which affected rather to fuzzy VIKOR.

This demonstrates the partially similar outcomes between fuzzy PROMETHEE II and fuzzy TOPSIS on the one hand and between fuzzy TOPSIS and VIKOR on the other hand.

For the other sectors, we had the same behavior concerning PROMETHHE II fuzzy and TOPSSIS fuzzy, the value was a bit high as the Transport sector which is equal to 0.999 and for fuzzy TOPSIS and fuzzy VIKOR, the value is equal to 0.979. For the correlation with the min- ranking, fuzzy TOPSIS, and fuzzy PROMETHHE II were on the same level with a value of 0.988.

The type of correlation to choose depends on the data type, but in our case, the two types of correlation produce an almost identical finding with small fluctuations.

The robustness of SPEARMAN stems from it lacks of sensitivity to the variable's typology.

4.3 Hard core study of methods

The objective of this study is to determine the ASP hard core that is linked to the frequency of the same positions for the four methods. The ASP is divided into four groups (A, B, C, D), with the level of each group varying based on the specifications and range of ASP to be retained. « A » denotes the certain and performant ASP, B the least certain, C the mediocre, and the D the ASP «to avoid». We have illustrated these groups with dynamic graphs.

We are just going to present the Transport sector study.

Table 13 shows the 4 groups that were created to classify the four methods

Table 13: Classification of methods according to 4 groups

Groups	A	B	C	D
The ranking margin	5	10	30	57

We observe that the top four ASP are classified among the top ASP for the four methods in the Transport sector, and they constitute the hard core by maintaining their positions for the 4 methods that vary within a range of [1,5].

Any variations in the classification interval margins will reduce the ASP's hard core in the case when the interval margin is reduced, for example, if we limit Group A to the value 3, we obtain the results presented in Table 19.

Table 14: Classification of the methods studied according to 4 categories

	Ranking				Groups			
ASP	VIKOR	AHP	PROMETHEE	TOPSIS	VIKOR	AHP	PROMETHEE	TOPSIS
Geodis Logistics Maroc	1	1	1	1	A	A	A	A
XPO Logistics	1	1	1	1	A	A	A	A
Bansard Maroc	3	3	3	3	A	A	A	A
Bolloré Logistics	4	5	4	4	B	B	B	B
Excel	41	35	37	36	D	D	D	D

The hard core of ASP in this scenario is made up of three ASP: « Géodis Logistics Morocco», « XPO Logistics », and « BANSARD Morocco ».

The more ASP with a higher number of A, in our case 4, are regarded to be better ASP, since all methods converge towards this choice.

The higher number of B in the ASP, the more converging methods towards a medium-high ranking ranging from 5 to 10.

We can also state that there is a general agreement on assigning the ASP to a data group, as seen by the assignment of scores of 4,3 or 0, but the assignment of scores 1 on the 4 methods is uncommon, this means that there is a consensus between the four methods.

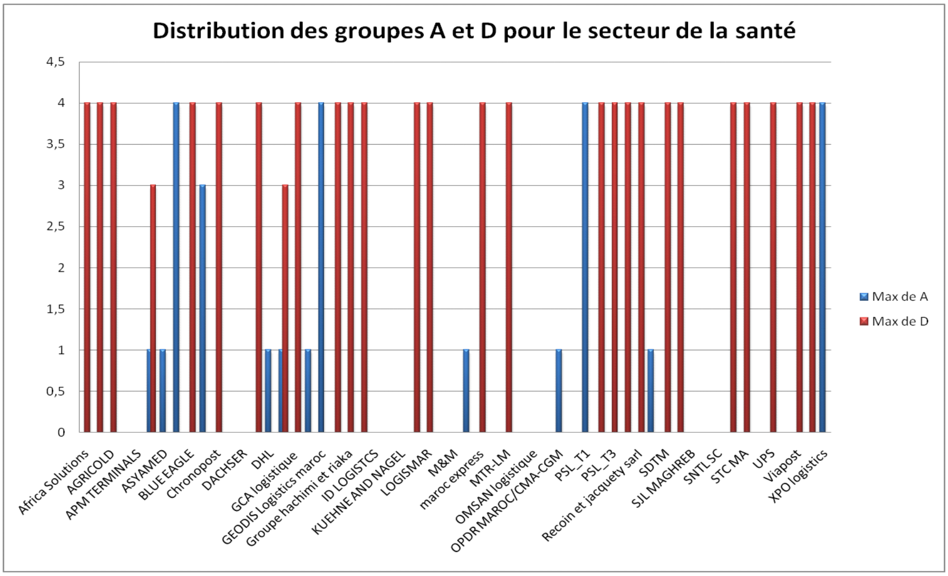

Figure 8: Dynamic distribution of groups A and D for the Transport sector

Source: own.

We visualize the ASP given to Group A that represent the top 5 ASP in terms of the criteria we have chosen, and those assigned to Group D that represent the ASP ranked bottom in terms of the level of their services taking into the account the criteria studied.

The greatest number of A is 4, reflecting the consensus of the 4 methods on the hard core that we have estimated at 5. BANSARD, XPO logistics, GEODIS, and BOLLORE are the ASPs assigned to it.

Therefore, the four methods chose these ASP from the top five ASP. However, for each of the four methods, the maximum number of D is given to many ASP.

5 Synthesis of 4 methods

Our study covered the evaluation of two aspects: the most robust ASP in terms of the criteria we specified, and the other aspect affecting the four methods we used. In addition, to ensure the relevance, feasibility, and good functioning of the 4 methods, we have implemented 3 witnesses ASP, ASP_T1, for which a maximum score of 5 was assigned for the five criteria, ASP_T2, with an average rating, and ASP_T3 with a minimum rating of 1 for all four methods.

The best ASP that has had a consensus of the four methods are: **Géodis logistics Morocco, Bansard Morocco,** and **XPO logistics.**

Based on the three indices we have chosen for the 4 methods, separability, correlation, and hard core, it turned out that fuzzy PROMETHEE II followed by fuzzy TOPSIS were able to obtain the best indices with virtually every classification having a single ASP.

Furthemore, fuzzy TOPSIS performed best at the level of correlation with a minimal ranking, whereas PROMETHEE II had a better SPERMAN correlation and a higher simple correlation.

6 Sensitivity analysis

Sensitivity analysis is an important concept in the effective use of quantitative decision models, it examines the stability of the results as the various parameters vary. In our case, our parameters concern the criteria scores and their priorities that will be represented by the decision-maker as well as the ASP scores for each service.

Therefore, the sensitivity analysis reinforces the multicriteria decision making (Feick & Hall, 2004), and according to (Insua, 1999), the sensitivity analysis determines how the results of quantitative analysis rest on input parameters.

In decision-making, the weightings assigned to decision criteria seek to indicate the real importance of these criteria. It is difficult to accurately reflect the relevance of criteria when they cannot be expressed in quantitative terms. The decision-maker can make better decisions, if he can determine the importance of each criterion (Mouine, 2011).

We will modify the parameters in a more or less random way that needs contemplation and intellect, and we will then analyze the changes through the results generated.

Given the introduction of the concept of randomness, we thought it was necessary to complete this analysis by defining stability intervals for the values obtained during classification, assigning them to each group, and evaluate the small differences between each value that correspond to a given ranking.

Ultimately, the basic subject of sensitivity analysis is the study in a model's input variables in order to examine their impact on the output variables, which is nothing other than decision-making and the selection of a suitable ASP.

7 Conclusion

Decision-making for several structures is a complex and unavoidable task to enhance their processes. This decision is involved in various sectors and the MCDA tools have been the subject of diverse applications in areas such as environment, energy management, economic planning, financial and banking management, urban management and transport, project evaluation and selection, production and supply management, etc.

This strategy has exploded with technological advancement as well as with globalization, especially with demands in terms of quality, technology, and worldwide competitiveness.

Through this paper, we have attempted to give an in-depth analysis of ASPs, using MCDM methodologies to show the best ASP. This choice was based on the priority of the criteria specified by the decision-makers varying according to each contractor's activity and field.

So, it was revealed that the problem of selecting ASP is one of the strategic decisions that has a considerable impact on the company's performance.

This situation has pointed out the importance of decision-making methods in influencing the ASP selection and, subsequently, the outsourcing strategy's success. Indeed, the development of the agricultures sector in Morocco constitutes a major challenge to economic growth and the strengthening of national and international competitiveness. However, to achieve the intended objectives, this strategy should be supported by effective decision-making tools by considering the criteria that have a great impact on the shattering and profitability of contractors, this is, for example, thanks to technology and traceability.

Furthemore, the diversification of the ASP's offer, whether national or international subsidiaries established in Morocco, makes choosing the best ASP more difficult. In fact, it is the central point of our research problem, where we are led to identify a method among a variety that will allow us to pick the best ASP, in the light of the exploratory study conducted on the situation of the offer of ASP operating in Morocco.

The study carried out highlighted and adjusted the existing methods to apply them to a sample of ASP operating in Morocco for choosing the best ones.

In perspective, we plan to develop an automated ASP's choice model, based on dynamic real-time research for the most satisfactory solution through an agriculture decision making system by using a mathematical and artificial intelligence method.

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