Chapter 6
Multicriteria Decision Support Model for Selection of Tinplate Suppliers:
A Case Study in CAN Company

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ABSTRACT

The evaluation and selection of suppliers has been an issue of great strategic importance over time. In this way, a structured evaluation is crucial, considering several criteria. This work reviews several multi-criteria decision support methodologies explored in the literature to solve the supplier evaluation process based on CAN company specifications, strategies, and requirements. Considering the characteristics of each supplier and a set of criteria with different weights, the AHP method and the PROMETHEE method are applied to establish a ranking according to the performance in the selected criteria. In addition, to help the company make the best decision, an analysis of ranking stability is performed by varying the weights assigned to the criteria. The study and models developed were easy to apply and understand, meeting the specified objectives.

INTRODUCTION

With the constant changes and demands of the market, the competition between supply chains has assumed global importance and an increasingly aggressive stance, requiring companies to make greater efforts to develop new management tools. Regardless of the sector in which companies are inserted,

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the activities related to the process of selection and evaluation of suppliers, are of extreme importance (Alencar, Almeida, & Mota, 2007).

The CAN company is a leading global company in the production of consumer goods packaging, where its main raw material is tinplate, which is acquired from several suppliers around the world. In this way, not being responsible for the production of this raw material, the evaluation and selection of suppliers is one of the critical activities so that the company obtains a competitive advantage.

The delivery of materials with quality problems, long lead times, high acquisition costs, among other things, can cause losses to the company. It is therefore extremely important to have a portfolio of reliable suppliers with positive characteristics.

Usually, suppliers tend to have similar characteristics to their competitors, which does not allow their evaluation and selection to be a simple process. In this way, a thorough evaluation of the criteria in supplier selection becomes crucial. However, this task frequently involves multiple criteria (quantitative and qualitative), which present different forms of measurement, thus being a multicriteria decision problem (Wang, 2010).

According to (de Boer, Labro, & Morlacchi, 2001), in industrial companies, as in the case of the company under study, the weight of purchases represents between 50% and 90% of its total turnover, which makes purchasing operations a determining factor for profit maximization.

In order to assist analysts and decision-makers in situations where there is a conflict of interests, considering a set of criteria, the Multicriteria Decision Analysis (MCDA) arise, which aim to help in choosing the best alternative (Gomes, Pereira, & Lins, 2002).

Applying two methods to support multi-criteria decision making, the **AHP** (Analytic Hierarchy Process) and **PROMETHEE** (Preference Ranking Organization Method for Enrichment Evaluation), the main intention is to obtain a ranking of the best suppliers. The application of both methods will allow to enrich the conclusions obtained, since, according to (Bruno, Esposito, Genovese, & Passaro, 2009), while the AHP approach structures the problem hierarchically, comparing judgments made by the decision makers (between alternatives and criteria) on a par and synthesizes in a simple way the priorities, the PROMETHEE method seeks to order potential alternatives by comparing them by pair, establishing a degree of preference, where the importance of each criterion is determined by the decision maker, by assigning a weight to it (Almeida, 2011).

The chapter is organized in 3 sections. Initially it addresses concepts, problems in supplier selection and multicriteria decision analysis. Subsequently, the methodologies of the criteria and the AHP and PROMETHEE methods will be deepened. Finally, both methods are applied in the evaluation of the suppliers of the CAN company in order to establish a ranking and to conclude which suppliers best fit the company's requirements.

BACKGROUND

1. Selection of Suppliers

The selection of suppliers should consider customer needs and the ability of the company has to meet those needs. Thus, it is considered that the initial point to start the process of production and distribution of a product, begins with the supplier (Sonmez, 2006). As stated by (Azadfallah, 2016; de Santis, Golliat, & de Aguiar, 2017; Rodrigues Lima-Junior & Ribeiro Carpinetti, 2016), supplier selection can be defined as a decision making process by which possible suppliers are review, evaluated and selected to become part of the company's supply chain.

According to (Mendes, 2013), supplier selection encompasses a range of variables that serve to filter the requirements to be met in accordance with the supply chain management process. It is increasingly intended to create a lasting relationship with the supplier, promoting trust and greater control over the production process, with the aim of creating barriers for new competitors (Mendes, 2013).

The problem in the selection of suppliers arises when a process of purchase of raw material is initiated, resorting to the current suppliers or the search of new suppliers (Cunha, 2008). According to (Dias, 2015), it is noted that there are high costs in the purchase of goods and, therefore, the company should consider the selection decision of suppliers based on several criteria. The supplier to be chosen must meet the necessary requirements to obey, in the agreed place, the desired quality and quantity.

The significance of the supplier selection comes from both external and internal aspects. Concerning the former, over the past few decades, supplier selection has gained even more importance due to the global markets and the increasing of competitive pressure. The growth in the number of competitors have force the companies to focus on core competences and to outsource less lucrative activities to suppliers (Ortiz-Barrios, Kucukaltan, Carvajal-Tinoco, Neira-Rodado, & Jiménez, 2017).

Therefore, competition has become a problem of supply chains rather than companies (Azadfallah, 2016). Suppliers have turn out to be key elements to acquire the products of higher quality in the required amount and time, at a cheap cost, and with the satisfaction of customer (Sarkar, Pratihar, & Sarkar, 2018; Valipour Parkouhi & Safaei Ghadikolaei, 2017). In this situation, supplier selection have emerged as a critical decision and buyer-supplier relationship have become more strategic and based on close collaboration and sustainability (Wetzstein, Hartmann, Benton jr., & Hohenstein, 2016).

The better the relationship between the company and the supplier, the more effective the entire production and distribution process of the products will be in the competitive environment that companies face. It is also a competitive advantage that becomes increasingly valued.

In this way, the company can operate more effectively and use the Lean and JIT philosophy (Ohno, 1997). Based on (Ho, Xu, & Dey, 2010), it is confirmed that the best choice of the supplier generates impact on the costs, performance and competitiveness of the company. This selection is considered reliable when considering quantitative and qualitative criteria.

According to (de Boer et al., 2001), the selection of suppliers is divided into two types: pre-qualification and decision. The supplier prequalification method encompasses qualitative methods, cluster analysis, Data Envelopment Analysis (DEA), linear weighting, and cost of ownership. The author also argues that the definition of the problem, the formulation and qualification of the criteria strongly influence the results in the choice of supplier.

The definition of the problem consists of selecting new suppliers, turning to usual suppliers, or producing in-house. After this filter, it is formulated the criteria that will satisfy the needs of the company. Subsequently, it will be the qualification phase that requires several steps for a method of elimination if the alternatives do not satisfy the selection rule. Once the qualification phase is identified, the final choice is based on ordering the suppliers and selecting them (de Boer et al., 2001).

The selection process, according to (Sonmez, 2006), is divided into two components:

- Evaluation and assessment process: identification of the criteria for scale creation and determination of the best and worst results. An attribute of the criterion can be subdivided into sub-attributes;

- Aggregation of evaluation in decision making: it uses scales based on the attributes previously indicated.

2. Multicriteria Decision Analysis (MCDA)

According to (Anderson, Sweeney, Williams, Camm, & Martin, 2011), problem solving integrates steps that are associated with the decision-making process. As shown in Figure 1, once the problem is identified and the alternatives and the criteria to be considered are identified, an evaluation is required that will aim at choosing an alternative. These phases are not only part of the problem-solving steps but are also associated with decision-making.

In everyday life, in fact they are considered not only an objective, criterion or point of view in decision making. In this sense, the multicriteria analysis serves as support in developing appropriate methodologies for, in the various situations, with multiple conflicting factors to be considered simultaneously, the option for an alternative in specific or classification/evaluation is simpler (Figueira, Greco, & Ehrogott, 2005).

As a tool to support decision-making, the multicriteria analysis emerged in the 1960s. In order to support organizations to make decisions that best suit their needs, even considering a number of criteria, the Multi-criteria Decision Making or Multi-criteria Decision Analysis presents a set of methods (Carmo, Neto, & Dutra, 2011; L. Ensslin, Giffhorn, R. Ensslin, Petri, & Vianna, 2010).

What differs from the multicriteria approach of traditional approaches to operational research is the concept of subjectivity that the multicriteria approach introduces (Costa, Brazil, & Oliveira, 2003). The same criterion can be analysed in different ways, depending on the decision maker that is evaluating, thus involving the subjectivity of the agents that are part of it.

Thus, the purpose of this analysis is to provide the decision maker with the best solution or recommendation among a finite set of alternatives, while being evaluated under different points of view, or in other words, different criteria. Nevertheless, and as (A. T. Almeida, 2011) alert, there is no solution that is simultaneously optimal for all criteria. Unlike the conventional techniques of Operational Research that are oriented towards the optimization of an objective function, the intention of the methods of multicriteria analysis is to find a solution that is more appropriate to the preferences of the decision maker.

There are several solutions to this problem that include methods such as Weighted Sum Model (WSM), Analytical Hierarchy Processes (AHP), Analytic Network Process (ANP), Data Envelopment Analysis (DEA), approaches such as PROMETHEE which consists in organization of preference ranking for

Figure 1. Relationship between problem-solving and decision-making
(Adapted from (Anderson et al., 2011))

enrichment evaluation, approaches based on Artificial Neural Networks (ANN), simple techniques for assigning multiple attributes (SMART), among others (Agarwal, Sahai, Mishra, Bag, & Singh, 2011).

According to (Mendes, 2013), multicriteria techniques can be subdivided into four categories:

- **Multi-attribute utility methods:** ANP e AHP (try to assign a value to each alternative)
- ***Outranking*:** ELECTRE e PROMETHEE (construct a binary preference relation for the whole potential of alternatives)
- **Compromise Methods**: TOPSIS e VIKOR (compromise solution is the closest solution to the ideal and evidences an agreement based on mutual concessions)
- **Other methods:** SMART e DEMATEL (sum of exact weights to generate rating indices)
- Based on (Kumar et al., 2017), multicriteria can be classified into three types:
    - Miscellaneous models: NAIADE
    - Utility-based model: SAW, AHP, MAUT
    - Model via prevalence: ELECTRE e PROMETHEE

According to these authors, this classification is complex since it covers several factors, such as social, economic or the selection of stakeholders. This procedure can be considered ambiguous since the objectives can create different solutions at different moments, according to the priority defined by the agents in the decision making.

The Hierarchical Analysis method, also known as AHP, allows a hierarchical structure to be defined, through several criteria and multiple decision making (Hatcher, 2008). According to (Forsberg, Mooz, & Cotterman, 2005), the decision-making process is easily structured, since to each criterion and alternative is applied a process to calculate its relative importance, allowing to obtain the best general alternative.

Based on (Roy & Vincke, 1981), the outranking methods are composed of two phases: the design of one or several prevalence relations over the alternatives, and later, in the analysis of the consequent relations in function of the formalization of the problem. The construction of a prevalence relationship implies a dominance relationship, in order to facilitate the resolution of the decision problem.

Based on (Terrientes, 2015), a prevalence relation is a binary relation of "*S*" defined in the set of alternatives A, such that, *aSb* translates into "*a* is at least as good as *b*", that is, *a* is not worse than *b*, where *a* and *b* are decision criteria. This method is successful because it is based on natural realistic assumptions inspired by the theory of social choice and intends to find the set of the best alternatives in comparison to the others. Therefore, the outranking methods do not consider strong assumptions about preference between alternatives, however, are rare cases in which a hierarchy of criteria is considered.

The PROMETHEE method consists in the construction of a value classification relationship, in which the decision maker establishes a weight for each criterion that increases according to its importance (Almeida & Costa, 2002).

METHODOLOGY

1. Definition of Decision Criteria

Over the years, the criteria cover aspects that go beyond the financial aspect, with an increase in the number of qualitative and intangible criteria, such as quality, delivery, performance, among others. With this addition of variables, complexity increases in the selection (Mendes, 2013). According to (Sonmez, 2006), the decision criteria can be the demographic characteristics of the purchasing managers, the size of the company, the acquisition strategy, the existence of a supply chain strategy and the type of products purchased. Other authors, as identified by (Mendes, 2013), Other authors, as identified by Mendes, determine new criteria such as cost of raw material, quality, service, experience, risk factors, knowledge of information technology, availability, environment, etc.

Based on (Dias, 2015), the criteria must meet the following requirements: easy to interpret, simple, clear, comparable, precise, universal and easily organized by hierarchy. After validation of the criteria, it is important to pre-evaluate them, to confirm the need to redefine and reduce the list of criteria to improve the decision-making process. It is also recommended that the number of criteria be identified in a range of three to seven, not exceeding nine to maintain consistency, simplicity and avoid abandonment, since too many criteria do not allow an individual assessment of the behavior of each (Dias, 2015).

The selected criteria were distributed as shown in Table 1.

The criteria referred to above will now be detailed in terms of definition.

- **Quality of Material –** the material delivered by the supplier must meet the minimum quality requirements set by the company. With more and more demanding customers, it is crucial to ensure the quality of products. In this way, a company that favours high quality parameters will achieve a strategic advantage over its competitors. In the company under study, in order to define the tinplate in terms of quality, the following criteria are generally considered: the quality, hardness and appearance of the tin. Being a qualitative criterion, it was necessary to transform qualitative data into quantifiable data, to be analysed and interpreted later.
- **Cost Acquisition –** this quantitative criterion refers to the cost that the company has to bear to acquire the raw material, which is considered in net terms and by Coil. Coil is the term assigned to a tin sheet coil. Being a cost to the company, it is intended to minimize it. It is necessary to find a balance between cost and benefit. Once there is a lot of suppliers in the market, the price of this becomes crucial in the negotiation and choice of suppliers.

Table 1. Definition of criteria

Supplier	Quality of Material	Cost Acquisition (€)	Logistic Lead Time (days)	Attendance Capacity	Certification	Flexibility	Financial Stability
1	4	909	56	3	2	3	4
2	4	954	56	4	2	3	4
3	2	630	110	1	1	1	2
4	3	801	70	2	2	3	3
5	3	783	110	1	1	1	3
6	2	774	110	1	1	1	4
7	2	765	110	1	1	1	4
8	3	918	70	2	2	2	3
9	2	792	110	1	1	1	4
10	3	936	110	1	1	1	3

(Source: Own)

- **Logistic Lead time–** lead time is the period of time it takes from the time the customer places an order to the delivery of the final product. In this way, the time it takes each supplier to complete the production of tinplate is crucial to ensure that the company can guarantee deliveries to customers on time in full (OTIF).
- **Attendance Capacity –** this criterion refers to the supplier's production capacity. In other words, the supplier's ability to respond to volumes ordered by the company. In a win-win logic, it is in the interest of both parties that, when the company orders a certain amount of material, the supplier can deliver it in full and not only partially.
- **Certification –** currently, certifications are part of the company's strategy as being indispensable. For this criterion there are two possible results: the supplier can be certified by the European standard *EN-10202-2001*, assuming the value 2; or Japanese standard *JIS G 3303_2008,* assuming the value 1. The European standard *EN-10202-2001* (CEN national Members, 2001) was drawn up by the Technical Committee ECISS/TC and specifies the requirements that must be met for products such as tinplate, specifying the quality standards, size, tolerances and specific tests to be performed. According to the experience of those responsible for purchasing department of this company, the European standard is more stringent and meets the requirements of conformity defined by the company, being preferred.
- **Flexibility –** the concept of flexibility is considered, in this context, such as the degree of ease with which the supplier, in the face of an unexpected or unforeseeable need on the part of the customers to whom it supplies, can anticipate the delivery of the raw material.
- **Financial Stability –** according to (Schinasi, 2004), the concept of financial stability is broad, including the role of financial infrastructure, institutions themselves and markets. In order to measure this criterion, aspects such as the number of factories it owns, the volume of invoicing and the number of responsible employees are considered.

2. Multicriteria Decision Methods

AHP Method: Analytic Hierarchy Process

The Analytic Hierarchy Process, better known as the AHP method, was developed by Thomas L. Saaty in the 1970s with the purpose of giving aid in making complex decisions, based on mathematics and psychology (Saaty, 1980).

As a methodology to measure, structure and synthesize a problem, the AHP method is widely used in multicriteria environments (Forman & Gass, 2001). According to these authors, the method comprises three functions:

1. The **measurement** through a scale defined by (T. L. Saaty, 1980) of positive and real numbers, ranging from 1 to 9, making possible the association to each element of a certain degree of importance, obtained through the binary comparison between the factors at various levels;
2. The **hierarchical structuring** of complexity, in an environment where there are several factors that are equally relevant in the decision making, allowing to order the problem in hierarchical levels, according to the characteristics of each element;

3. **Synthesize**, that is, combine the multiplicity of factors in a hierarchy. Based on the weight of the factors and in the preferences of the decision makers, to obtain a final ranking with the classification of the alternatives.

In this way, the AHP method allows to structure a complex problem in a hierarchy, comprising at least three levels: objectives, criteria and alternatives (Saaty, 2008).

According to (Saaty, 1991, 2008), the application of the AHP method is summarized in four steps:

- Define the problem, establish the objectives and the type of knowledge that is needed;
- Hierarchical decomposition of the decision problem: it comprises a higher level, the general objective, following the criteria to be taken into account in the decision problem, and finally, a last level that is represented by the possible alternatives. The criteria may also be subdivided into subcriteria, depending on the decision problem to be addressed.
- Once the logical hierarchy is constructed, a set of square matrices is constructed, where comparisons are made alongside the criteria and the alternatives, whose objective is to establish a relative importance among the elements. In a first step, for each criterion a comparison is made in pairs. Subsequently, in a second stage, the alternatives for each criterion are compared. To convert human perception into numbers, the Fundamental scale of Saaty is used (Table 2).

As shown in Table 2, the fundamental scale of (TL Saaty, 1980), ranges from 1 to 9, where the value 1 expresses indifference in the selection of one element in relation to another, that is, one is equally preferable in relation to, and, on the other hand, the value 9 indicates that one element is absolutely preferable in relation to another. It should also be noted that one of the assumptions made is reciprocity in the comparisons made, that is, if, for example, it is considered by the decision-maker that the comparison of pairs from criterion A to criterion B assumes the value 3, then the comparison of criterion B pairs in relation to criterion A assumes the ratio of 1 to 3 (T. L. Saaty, 1980).

Table 2. Fundamental scale of Saaty

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective.
3	Moderate importance of one over the other	Experience and judgment slightly favor one activity over another.
5	Strong or essential importance	Experience and judgment strongly favor one activity over another.
7	Very strong or demonstrated importance	An activity is strongly favored and Its dominance demonstrated in practice.
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation.
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When you are looking for a compromise condition between two settings.
Reciprocals	If activity i has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i.	

(adapted from (T. L. Saaty, 1980))

According to (T. L. Saaty, 1980) in the elaboration of the square matrices or decision matrices, where i represents the line number of the matrix, j the columns and a_{ij} represents the comparison between criteria and alternatives A_i and A_j, the following rules must be respected:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \tag{1}$$

where,

1. $a_{ij} = \frac{1}{a_{ji}}$, so, if $a_{ij} = k$ then $a_{ji} = \frac{1}{k}$ for all $k>0$;
2. $a_{ii}=1$ for all i. That is, any criterion compared to itself assumes equal importance in the fundamental scale.

Based on (T. L. Saaty, 1991), subsequently the decision matrices are normalized in order to obtain the relative weights (w), this normalized matrix being defined by:

$$A' = \left[a'_{ij}\right] \tag{2}$$

where, $a'_{ij} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{ik}}$ for $1 \leq i \leq n$, and $1 \leq j \leq n$.

Normalized to the matrix, in order to determine the relative weight of each alternative, the average value in each line is calculated, being determined by (T. L. Saaty, 1991):

$$W = \left[w_k\right] \tag{3}$$

where, $w_k = \frac{\sum_{k=1}^{n} a'_{ij}}{n}$ for $1 \leq i \leq n$, e $1 \leq j \leq n$.

Since a_{ij} are values that are based on subjective judgments, it means that the values they assume may have a deviation from the ideal ratio, and it is crucial that, in order to ascertain if the propositions made are minimally plausible, be measured the consistency of the matrices (T. L. Saaty, 1991).

If $A=[a_{ij}]$ is a matrix of $n \times n$ positive elements, then $a_{ij} = a_{ji}^{-1}$, such that, A is consistent, if and only if, the eigenvectors $\lambda_{max} \geq n$.

Thus, to measure consistency, we will base two axioms (T. L. Saaty, 1991):

- There exist eigenvectors λ_i, $i=1,2,\ldots,n$, such that $AX=\lambda X$ (where X is a vector of weights).

If the matrix *A* is consistent, then all the eigenvectors assume a value equal to 0, with the exception of one that will assume a value *n*, the maximum value of λ_i;

- If the diagonal of matrix *A* assumes values with a_{ij}=1 and considering that A is consistent, then the largest eigenvectors λ_{max} with small variations of a_{ij} will remain close to *n* and the remaining eigenvectors close to 0.

Thus, it is necessary to determine the proper vector *w* of weights that obeys the following equation:

$$Aw = \lambda_{max} w \tag{4}$$

The eigenvectors of weights *w* will determine the disposition by level of relevance of the elements corresponding to matrix *A*, since it considers the actual weights given to the elements that were being compared.

Finally, in order to evaluate the proximity between λ_{max} and *n*, that is, to verify whether the evaluations were consistent or not, it is necessary to calculate the Consistency Ratio (*CR*) which correlates the Consistency Index (*CI*) with the Random Consistency Index (*RI*), and is given by the following expression:

$$CR = \frac{CI}{RI} \tag{5}$$

The Consistency Index (*CI*) s obtained by the following formula (T. L. Saaty, 1991):

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{6}$$

where, *n* is the number of elements (criteria or alternatives).

The values for the Random Consistency Index are obtained from Table 3.

According to (Saaty, 1990), the value of *CR*, to indicate consistency, can take as maximum value 0.10. However, if the result is greater than this value, the evaluation process must be repeated to establish consistency for acceptable values.

- Finally, in order to establish priorities (that is, to define a global ranking), use the precedencies previously obtained in the comparisons.

Table 3. The RI values

Matrix Size	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

(adapted from (Saaty, 1987))

Method PROMETHEE: Preference Ranking Organization Method for Enrichment Evaluation

The PROMETHEE method is based on the ordering of a finite set of actions, where a given weight is assigned to each criterion, taking into account its importance. Thus, preference is calculated by combining pairs of alternatives, considering the deviation between two alternatives in a single criterion. This means that the higher the deviation, the higher the preference (Morte, 2013). (Rezaei-kelidbari, Homayounfar, & Foumani, 2016) argue that this is a method for a finite set of actions that will be classified and selected among the criteria, which may generate conflict. It is quite simple to apply comparatively with the other methods for analysis of multiple criteria.

PROMETHEE I and II, were the first of this family of methods to be developed by Jean-Pierre Brans, having been presented for the first time in 1982 (Brans & Mareschal, 2005).

Since then, other methods of the family have been continuously developed, as illustrated in Table 4.

According to (A. T. Almeida, 2011), in the first stage a weight w is established for each criterion, which reflects its relative importance. From this point it is possible to obtain a degree of preference that the criterion a has on b, for each pair of alternatives through the following expression:

$$\pi\left(a,b\right) = \sum_{i=1}^{n} w_i P_i\left(a,b\right) \tag{7}$$

where,

$$\sum_{i=1}^{n} w_i = 1 \tag{8}$$

Table 4. PROMETHEE family of methods

Method	Problematic	Characteristic
PROMETHEE I	Choice	Partial pre-order
PROMETHEE II	Ordering	Complete pre-order
PROMETHEE III	Ordering	Stochastic treatment of flows (interval preference)
PROMETHEE IV	Choice and sorting	Continuous set of actions
PROMETHEE V	Ordering	Full pre-order including targeting restrictions
PROMETHEE VI	Choice and sorting	Pre-order complete or partial
PROMETHEE-GAIA	Extension of PROMETHEE results	Visual and interactive procedure

(Adapted from (Brans & Mareschal, 2005)) and $P_i(a,b)$ – Preference function that depends on the difference between the performance of the alternatives for each criterion i, d_i, where $d_i = g_i(a) - g_i(b)$.

Presented by (Brans & Mareschal, 2005), there are six preference functions used in PROMETHEE that allow the decision maker to express their preferences in a more timely manner to each criterion, which are illustrated in Figure 2, where:

p corresponds to a threshold of preference, that is, the lowest value for d_i above which there is a strict preference among alternatives;
q corresponds to the indifference threshold, that is, the highest value for d_i above which there is an indifference between the alternatives;
s is an intermediate value between p and q, which follows a normal distribution;
Valor 1 – strict preference;
Valor 0 – indifference.

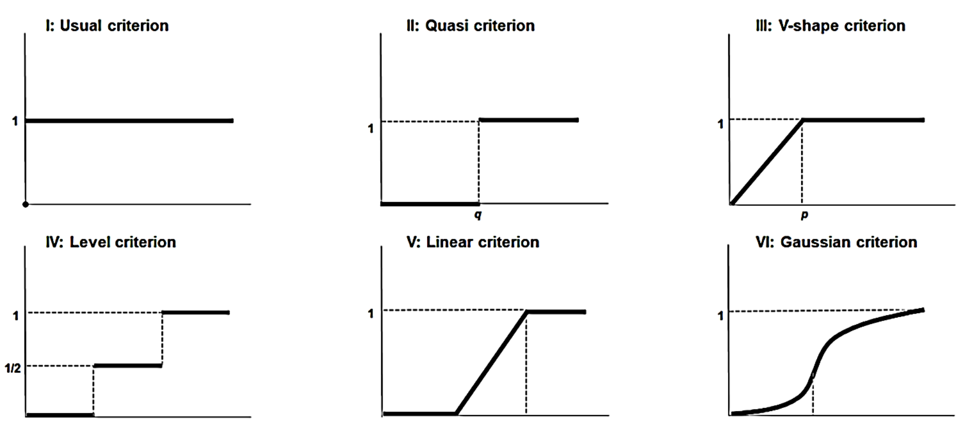
After the first phase, two indicators are used to evaluate the preference relationship between alternatives (Brans & Mareschal, 2005), the positive preference flow, $\phi^+(a)$, and the negative preference flow, $\phi^-(a)$, which admit values between -1 and 1.

The positive preference flow reflects the intensity with which an alternative surpasses all others, that is, the greater the value of $\phi^+(a)$, the better the alternative. On the other hand, the negative preference flow shows the intensity with which an alternative is exceeded by the others, that is, the lower the value of $\phi^-(a)$, the better the alternative (Brans & De Smet, 2016).

Finally, in order to extrapolate a complete pre-order, the global flow of the alternative ($\phi(a)$) resulting from the difference between $\phi^+(a)$ and $\phi^-(a)$ is used, comprising values on a scale which goes from -1 to 1. Thus, the higher this value, the better sorted will be the alternative (Brans & De Smet, 2016).

In a multicriteria problem, it is not always easy to compare two alternatives, since one can be much better in one set of criteria and the other better in another set of criteria, that is, decision-making often involves evaluating criteria that are conflicting. In this way, different forms of evaluation (considering, respectively, the values of ϕ^- and ϕ^+) can culminate in different rankings (Mareschal, 2013).

Figure 2. Preference functions used in PROMETHEE - graphical representation
(Adapted from (Brans & De Smet, 2016))



The PROMETHEE I, is a cautious indicator, as it confronts the two rankings obtained for both ϕ^+ and ϕ^-, including only the preferences that are confirmed in both rankings. For this reason, it is denominated as partial ranking, in the sense that, when two rankings are not consensual for a given alternative, no comparison is made, introducing the concept of incomparability between actions (Mareschal, 2013).

However, PROMETHEE II presents a complete ranking, considering, like the flow table, the global flow ϕ which, as previously mentioned, results from the difference between ϕ^+ and ϕ^- of each supplier, being all the better, the greater the value obtained (Mareschal, 2013).

The PROMETHEE GAIA is used to minimize the loss of information, starting from a multidimensional representation of the decision problem. The objective is to graphically describe the main characteristics of the decision problems, determining if the alternatives are different or similar from each other, which criteria conflict, what is the impact of the weighting assigned to the criteria in the ranking obtained, among other aspects (Mareschal, 2013).

(Brans & Mareschal, 2005) state that the analysis of the GAIA plan helps the decision maker to perceive the structure of the problem, being the best two-dimensional representation of the multicriteria problem, since it provides information on three crucial points, namely:

- Actions, which are represented by points;
- Criteria, which are represented by axes;
- Weights of the criteria, which are represented by the decision axis.

In practice, the 2D representation is considered reliable when the quality level is higher than 70%.

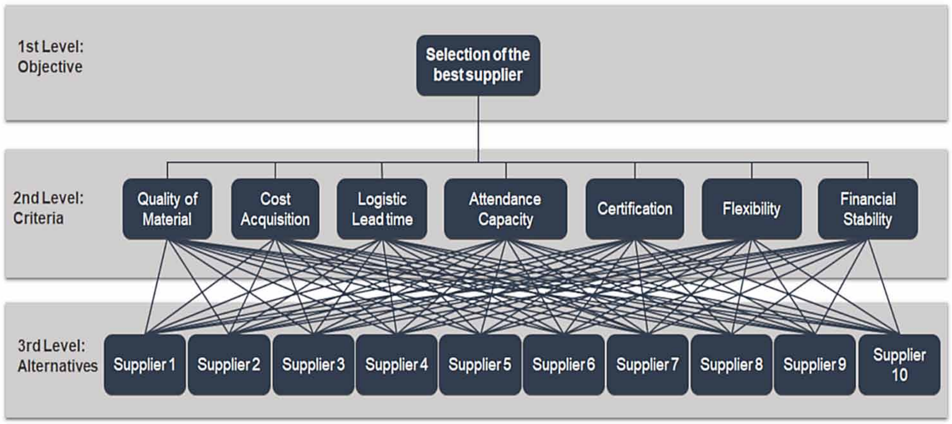
APPLICATION OF METHODOLOGY OF MULTICRITERIA ANALYSIS: RESULTS / DISCUSSION

1. Problem Identification and Structuring

For the process of collecting and obtaining data for subsequent employment in the selected models, it was necessary to access the database of the company's computer system for the collection of quantitative data and, on the other hand, to collect qualitative data, hold informal meetings with those responsible for the company's purchasing department. In this way, the criteria and the possible alternatives were indicated by the professionals responsible for the purchasing department of the CAN company, who work daily with the suppliers and know closely the relevant aspects of the raw material in question, tinplate, for the productive process. The main objective will be to establish a ranking of the best suppliers, so that the company can make decisions in this scope.

As for the PROMETHEE method, the weight assigned to each criterion was also indicated by the buyers of this company. The same happens when it comes to the AHP method, where the trade-offs determined in the pairwise comparison of the alternatives and criteria are carried out jointly with the decision makers of the purchasing sector.

Figure 3. Problem hierarchical structure
(Source: Own)



2. Application of the AHP Method

In order to apply the AHP method in this study, it was considered a hierarchical structure that Figure 3 illustrates.

At the top of the hierarchical structure is the main objective, the selection of the best supplier. Below is the second level that includes the seven criteria considered for the evaluation process, and finally, in the third level, there are the ten possible alternatives of suppliers.

Once the hierarchies have been defined, it is necessary to compare in pairs a total of 7 criteria of the second level in relation to the first hierarchical level. For this comparison the fundamental scale of (T. L. Saaty, 1980), as referred in Table 1. At this stage the objective is to establish the relative importance of each criterion in the objective to be fulfilled.

If there is only one element in the first hierarchical level, only one matrix is constructed with the intention of measuring the degree of intensity in pairs according to the seven criteria.

Then, this matrix is normalized, matching all the criteria to the same unit, dividing each value of the matrix by the total of its column. Thus, by calculating the mean value is obtained the weight assigned to each criterion, that is, the relative importance that each criterion has in selecting the best supplier (Table 5).

As shown in Figure 4, the criterion "Cost Acquisition" is one that, according to the evaluation of the decision makers, represents a greater portion in the final choice, followed by the criterion "Quality of Material" weighing about 27% . In this way, the cost criterion will be the one that will impact the objective more, following the criterion "Quality of Material". With a lower portion, "Lead time Logistic" appears, with a weighting of about 14% in the final decision. Regarding the criteria "Attendance Capacity", "Certification" and "Flexibility", these have the same impact on the selection of the best supplier, having a weight of about 6%. Finally, and with a relative lower importance, the "Financial Stability" criterion appears, which although important for the evaluator is less important than the other criteria.

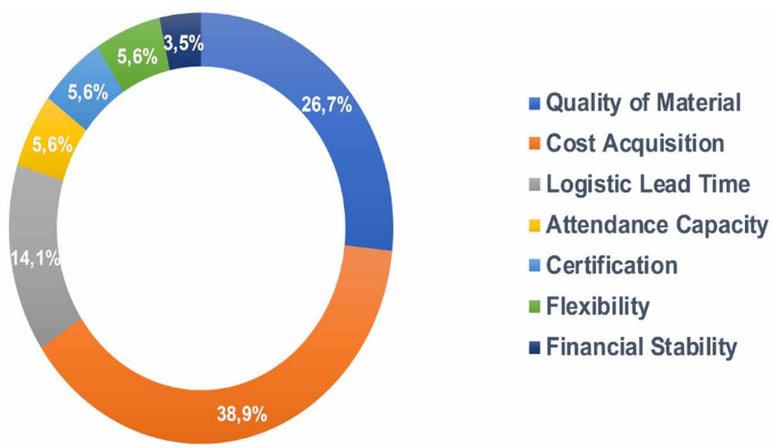
The next step is to carry out the consistency test of the comparisons made, trying to verify if the evaluations are logically related. For this, the element that corresponds to the greatest importance (λ_{max}) that is obtained through the sum of the products of the column vector w_n, obtained in Table 5, is calculated with the sum vector of the matrix.

Table 5. Standard matrix and its weight for each criterion

Matrix A Normalized	Quality of Material	Cost Acquisition	Logistic Lead Time	Attendance Capacity	Certification	Flexibility	Financial Stability	Weight (w_n)
Quality of Material	0,2439	0,2095	0,3636	0,2703	0,2703	0,2703	0,2400	26,7%
Cost Acquisition	0,4878	0,4190	0,3636	0,3784	0,3784	0,3784	0,3200	38,9%
Logistic Lead Time	0,0813	0,1397	0,1212	0,1622	0,1622	0,1622	0,1600	14,1%
Attendance Capacity	0,0488	0,0599	0,0404	0,0541	0,0541	0,0541	0,0800	5,6%
Certification	0,0488	0,0599	0,0404	0,0541	0,0541	0,0541	0,0800	5,6%
Flexibility	0,0488	0,0599	0,0404	0,0541	0,0541	0,0541	0,0800	5,6%
Financial Stability	0,0407	0,0524	0,0303	0,0270	0,0270	0,0270	0,0400	3,5%
Sum	1	1	1	1	1	1	1	100%

(Source: Own)

Figure 4. Relative weight of each criterion
(Source: Own)



Then, the Consistency Index (*CI*) and the Consistency Ratio (*CR*) are calculated. As the value of *CR*<0,10, then it can be concluded that the comparisons made are consistent.

The next step is to perform the pairwise comparison of each element of the third level with each element of the second hierarchical level, that is, the comparison of suppliers with each other, regarding the performance in each of the criteria.

The final step of applying the AHP method to the problem under study is to use the weights (w_k) obtained by supplier in each criterion, weighted by weight (w_n), both values obtained in the previous steps. In order to obtain a ranking of the best suppliers, we calculate the weighted average of these parcels, which will allow to find the final value of importance of each supplier and establish priorities. Table 6 presents a summary table with the global ranking obtained.

With the application of the AHP method, it is concluded that the best performance was from supplier 1 with 16,16%, followed by supplier 2 with about 15,56%. Although these suppliers perform very

Table 6. Ranking of suppliers

RANKING		
1º	Supplier 1	16,16%
2º	Supplier 2	15,56%
3º	Supplier 3	13,56%
4º	Supplier 4	11,70%
5º	Supplier 8	8,94%
6º	Supplier 5	8,33%
7º	Supplier 7	7,81%
8º	Supplier 6	7,15%
9º	Supplier 9	5,76%
10º	Supplier 10	5,04%

(Source: Own)

closely, with a difference of only about 0,6%, which distinguishes favourably the first supplier of the second, it is the lowest price it presents. On the other hand, Supplier 2 stands out positively from Supplier 1, when the criterion of Attendance Capacity is analysed. However, since the cost of acquisition is the criterion with greater weight in the final decision, it is the one that has the most impact in the decision vector, since, while the cost of acquisition has a weight of about 39% in the final choice, the Attendance Capacity only weighs in 6%.

Observing in detail the criteria "Cost Acquisition", since it is one that has more impact on the final selection, it is possible to conclude that the supplier that performs more favourably (about 30%) is the supplier 3. However, this supplier only ranks 3rd in the ranking. Although it has the lowest cost, it performs negatively on the other evaluation fields, since the quality of the material, the second criterion that weighs most in the decision, is only reasonable, as is the financial stability. On the other hand, this supplier is governed by the least beneficial standard, the Japanese standard, has a flexibility and a weak service capacity and, finally, a very long lead time (of about 110 days), double the lead time that the suppliers 1 and 2 have.

Below the supplier 3, the supplier 4 appears, although having good material quality and financial stability and, on the other hand, following the standards defined by the European standard, has a cost acquisition of € 801/coil, a lead time of 70 days and an attendance capacity that is not of the best.

Finally, in the last places of the ranking, the suppliers 9 and 10 appear. The supplier 9 demonstrates a more favourable performance in relation to the supplier 10, occupying the penultimate position of the ranking, since, despite having a low performance in all the criteria, it has a lower acquisition cost than the supplier 10, achieving position ninth. The supplier 10, when presenting a cost of acquisition of the highest, although having a good material quality, does not compensate it in the other criteria, obtaining a low performance, being classified in the last position.

In order to determine the weight variation of each criterion that will result in the fact that the chosen alternative is not selected, a sensitivity analysis was performed.

This analysis makes it possible to gauge the robustness of the choice of supplier 1, and the choice could only change with a relatively different opinion on the part of the decision makers, the heads of the purchasing department of CAN. The cost acquisition is the criterion that presents the most sensitivity in the variation of its weighting and this is perceptible given the nature of the criterion in question. Considering the current weight of the criterion "Cost Acquisition" (39%), the selected option is the supplier 1. However, lowering this criterion from 39% to 20%, the preferred option becomes supplier 2. On the other hand, increasing the weighting of this criterion by 6%, the option selected becomes the supplier 3, being this the supplier with the most competitive price. For the criterion "Quality of Material", which currently has a weight of 27%, the selected alternative is the supplier 1. Only with a reduction of more than 10 percentage points in the weight of this criterion, is the supplier 1 no longer the best positioned in the ranking.

Regarding the criteria "Certification", "Flexibility" and "Financial Stability", in all three cases the selected option is the supplier 1, regardless of the weighting assigned.

The criteria "Lead time Logistic" and " Attendance Capacity ", with only a reduction of more than 10% in the first criterion and an increase in the weight assigned to the second criterion to more than double, is that supplier 1 ceases to be the chosen one, wherein in the first case the supplier 1 gives place to the supplier 3 and in the second case, the supplier 2.

3. Application of the PROMETHEE Method

In the PROMETHEE method pairwise comparisons are made for the alternatives, indicating the performance of each alternative in relation to each criterion (Brans & Mareschal, 2005). However, unlike the AHP method, where the decision makers make a set of judgments to express the relative importance that each criterion taking into account the fundamental scale of (T. L. Saaty, 1980), in the PROMETHEE method is assigned a weight for each criterion, which reflects its relative importance, that is, it assumes that the decision maker can weigh the criteria adequately (A. T. Almeida, 2011).

In the problem under study, the weights assigned to each criterion consider the importance that each takes in decision-making by purchasers of tinplate CAN company, which have a high technical knowledge about this stuff, interacting daily with suppliers. This is the weight that the decision-makers responsible of the purchasing department consider in the selection of suppliers, which will be, in turn, reflected in the PROMETHEE method.

The PROMETHEE & GAIA software was used to support the PROMETHEE Method, which resulted in the interface below. In column, the criteria are listed and, in line, the available alternatives. In this way, a set of 7 criteria and 10 suppliers is presented, as shown in Figure 5.

a. Network

For this indicator each action is represented as a node and preferences are represented by arrows. The nodes are located in relative positions corresponding to the PROMETHEE Diamond, so that the proximity

Figure 5. PROMETHEE software interface
(Source: Visual PROMETHEE)

Empresa CAN	Quality	Cost	Leadtime	Capacity	Certification	Flexibility	Financial
Unit	Scale 1-4	€	Days	Scale 1-4	Scale 1-2	Scale 1-3	Scale 1-4
Cluster/Group							
Preferences							
Min/Max	max	min	min	max	max	max	max
Weight	2,00	3,00	1,50	1,00	1,00	1,00	0,50
Preference Fn.	Usual	V-shape	V-shape	Usual	Usual	Level	Level
Thresholds	absolute	absolute	absolute	absolute	absolute	absolute	absolute
- Q: Indifference	n/a	n/a	n/a	n/a	n/a	0,89	0,64
- P: Preference	n/a	200,00	49,32	n/a	n/a	1,89	1,39
- S: Gaussian	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Statistics							
Minimum	2,00	630,00	56,00	1,00	1,00	1,00	2,00
Maximum	4,00	954,00	110,00	4,00	2,00	3,00	4,00
Average	2,80	826,20	91,20	1,70	1,40	1,70	3,40
Standard Dev.	0,75	96,08	23,45	1,00	0,49	0,90	0,66
Evaluations							
Supplier 1	Very good	909,00	56,00	Good	European	High	Very good
Supplier 2	Very good	954,00	56,00	Very good	European	High	Very good
Supplier 3	Reasonable	630,00	110,00	Weak	Japanese	Low	Reasonable
Supplier 4	Good	801,00	70,00	Reasonable	European	High	Good
Supplier 5	Good	783,00	110,00	Weak	Japanese	Low	Good
Supplier 6	Reasonable	774,00	110,00	Weak	Japanese	Low	Very good
Supplier 7	Reasonable	765,00	110,00	Weak	Japanese	Low	Very good
Supplier 8	Good	918,00	70,00	Reasonable	European	Average	Good
Supplier 9	Reasonable	792,00	110,00	Weak	Japanese	Low	Very good
Supplier 10	Good	936,00	110,00	Weak	Japanese	Low	Good

between the flow values appears clearly. That is, it relates suppliers that have dominance over others and isolates suppliers that are incomparable. It resorts to ϕ^- and ϕ^+ to determine dominance, that is, if ϕ^+ is superior relative to another, then there is one vendor that dominates. In the case of ϕ^- it treats inversely, the lower the value, the more dominant the supplier.

The supplier 10 reveals the lowest ϕ^+ and the highest ϕ^- compared to the others, with 0.09 and 0.41 respectively. The best suppliers are suppliers 1 and 2, with ϕ^+ of 0.55 and 0.54 and with ϕ^- of 0.15 and 0.19, respectively. This means that the best suppliers show a higher ϕ^+, with a difference of 0.46 (supplier 1) and 0.45 (supplier 2) values above the last one, in addition to having a lower ϕ^- of about 0.22 when compared to the supplier 2, and about 0.26 when compared to supplier 1. This represents a significant difference in the determination of the preference of the selection and a more evident disparity between the remaining suppliers.

Interpreting the hierarchy of the diagram of Figure 6, it is verified that:

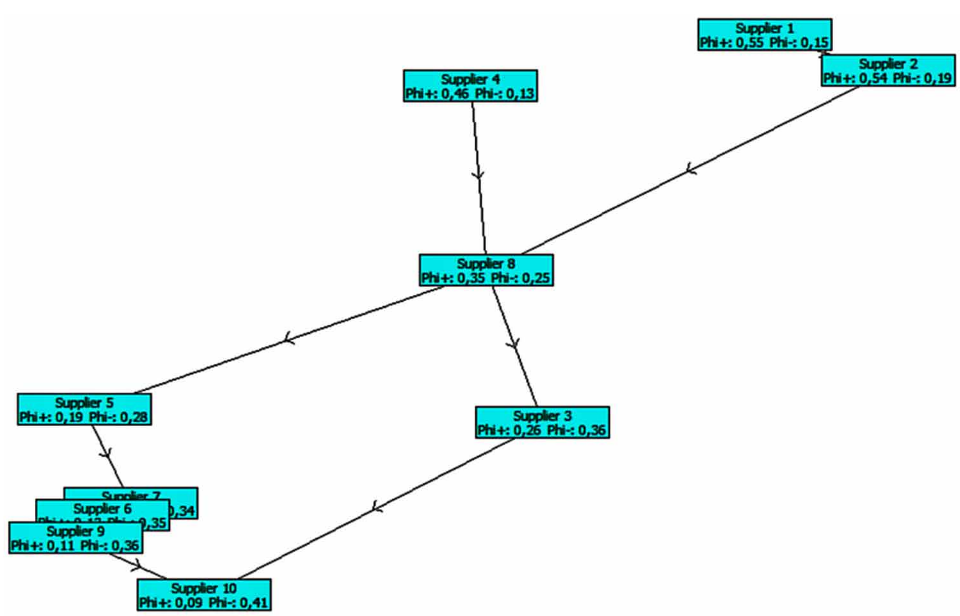
- The supplier 10 is easily surpassed by the suppliers 9, 6 and 7, as they positively vary the cost and stability, unlike the supplier 10 which only demonstrates a quality of the raw material above these suppliers;

- The supplier 3 also overlays the supplier 10 since it carries a substantially lower cost, promoting ϕ^+, notwithstanding the financial stability and the quality of the good that are unsuitable for the requirements of the decision maker, which promotes that ϕ^- is less than the supplier 10;
- Suppliers 9, 6 and 7 are below supplier 5 (with ϕ^+ of 0.19 and $\phi^-$of 0.28). This does not establish a comparison with the supplier 3, since the ϕ^+ is inferior, notwithstanding the ϕ^- being smaller, that is, it establishes a relationship of incomparability. All of these suppliers are homogeneous as a result of extended lead time, attendance capacity and flexibility of anticipation of orders are weak, as well as being governed by Japanese certification;
- Vendor 8 dominates suppliers 3 and 5, because ϕ^+ is higher and ϕ^- is lower with 0.35 and 0.25 respectively. It holds the criteria more favourably, except in the cost of acquisition that assumes a higher value. It should be noted that when compared to the supplier 5, the supplier 8 exhibits the same quality of the material and is classified as having the same level of financial stability;
- The provider 4 (with $\phi^+$of 0.46 and ϕ^- of 0.13) is superior compared to the supplier 8, and establishes a relation of incomparability for suppliers 1 and 2, since it has, on the one hand, a lower ϕ^+ and, for other side, a lower ϕ^-;
- The supplier 1 shows the best results, since it assumes a higher ϕ^+ and a lower ϕ^- with respect to the supplier 2. The latter, has all the positive criteria but a higher raw material cost.

b. PROMETHEE GAIA

As previously mentioned, PROMETHEE GAIA is the best two-dimensional representation of the multicriteria problem, providing information regarding the alternatives, criteria and weights of the criteria (Brans & Mareschal, 2005).

Figure 6. Network
(Source: PROMETHEE-GAIA software)



A first aspect to consider is the fact that the 2D representation obtained has a quality level of 89,7%, which means that it is extremely reliable.

For actions or alternatives, these will be similar the closer they are, and vice versa. Analysing the obtained graph, the suppliers 1 and 2 are very close to each other, being considered actions with similar characteristics. On the other hand, suppliers 4 and 8 also appear close to each other, thus concluding that they are analogous alternatives.

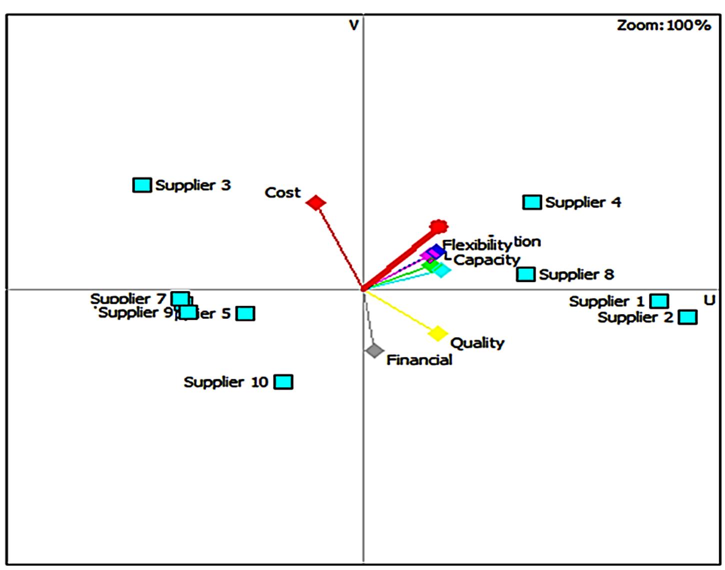
However, the supplier 3, being isolated from the other suppliers, is considered disparate from the others. In fact, considering the values of the criteria, the supplier 3 is the one that exhibits the lowest cost, however, in the other criteria the same values as the suppliers 6, 7 and 9, except for the financial stability that, while these have excellent stability the supplier has only a reasonable financial stability. Finally, in the same quadrant, but further away, the supplier 10 appears, which, although similar in all respects to suppliers 5, 6, 7 and 9, the major difference lies in the price which is substantially higher. This aspect means that, although the supplier 10 is in the same quadrant distances himself from the other suppliers.

As for the criteria, these are portrayed by axes drawn from the center of the plane, where criteria with an analogous preference will be represented by axes oriented in similar directions. On the other hand, criteria with divergent or conflicting preferences are portrayed by axes with opposing directions.

In this case, the axis that represents logistic lead time, attendance capacity, flexibility and certification exhibit the same orientation, these criteria being very close, indicating that they assume a similar behaviour.

The cost, appearing isolated, indicates that it conflicts with the other criteria. Looking at the detail, it is noteworthy that, for example, observing suppliers 1 and 2, in spite of practicing a high price, are suppliers with a more favourable performance in the other criteria. It is possible, therefore, that when the price is analysed in parallel with the quality, it turns out that the company will have to make a trade-off between quality/price, in the sense that the best quality suppliers will be those who practice higher prices.

Figure 7. PROMETHEE GAIA
(Source: PROMETHEE-GAIA software)



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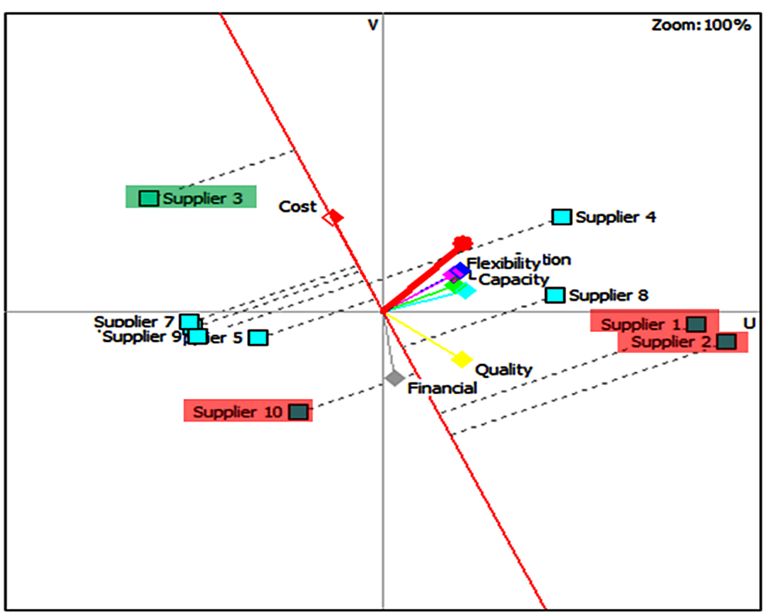
The same analysis can be carried out with the other criteria. When comparing the certification with the price, it is concluded that the suppliers who practice the highest price are governed by the European standard, with the exception of the supplier 10 who, practicing the second highest price in the table, follows the Japanese standard and not the standard considered most beneficial to the CAN company, the European standard. In this way, there is a conflict of interest since, when the decision maker seeks the raw material at the lowest cost, it will have to make several trade-offs, since it will find a favourable price performance, but the same may not occur in the other criteria.

Finally, the criterion of "Quality of Material" appearing below the logistic lead time criterion, attendance capacity, flexibility and certification, with a relatively identical direction, indicates that these criteria, not being completely consensual, also do not reveal a completely different behavior. Conversely, by displaying an axis with an entirely opposite orientation, the criterion of the acquisition cost indicates a total divergent preference. When analysing the values of these two criteria, it is found that, in order to obtain a high quality of the raw material, a higher price is requested and there is, therefore, a conflict of interests and a trade-off that the decision makers will have to consider and in decision-making, as mentioned in the previous paragraph.

As for the criterion of financial stability, there are suppliers who, despite having a high performance, are charged with higher prices. On the other hand, the supplier 3, being the one who practices the lowest price, is also the supplier with less financial stability, existing conflict. Looking at the quality of the material in parallel with this criterion, since both axes are relatively close (albeit with a slightly different orientation), it is perceptible that suppliers with excellent financial standing reveal a very good quality for suppliers 1 and 2, or only reasonable, as is the case with suppliers 6, 7 and 9.

In addition to the orientation of the axis, its size is also relevant, since it indicates how the variation observed in a criterion is more or less important.

Figure 8. PROMETHEE GAIA with the axis of the criterion "acquisition cost" evidenced
(Source: PROMETHEE-GAIA software)



Contemplating simultaneously the relative positions of alternatives and criteria, the information to be extrapolated is quite interesting.

Analysing the cost criterion (Figure 8), since this is the one that weighs the most in the choice of the best supplier, it is verified that the supplier 3 is the one that is more aligned with the orientation of the axis of this criterion, positioning to the left, demonstrating that this supplier is the best ranked in this criterion. However, suppliers 1, 2, 8 and 10, practicing the highest prices, are in the opposite orientation to this criterion and at the same time more distant.

As for the criterion "quality of the material" (Figure 9), suppliers 1 and 2 assume the preference, being positioned more to the right of the axis to yellow stroke, having a quality considered very good. Next to these suppliers and, moving in the axis to the left, the suppliers 8, 4, 10 and 5 appear, being the suppliers that have a good quality of the material. Finally, the remaining suppliers, who are still further left on this axis, are the worst suppliers classified in this criterion, with a raw material quality considered only reasonable (suppliers 3, 7, 6 and 9).

In order to assess the robustness of the obtained ranking, a sensitivity analysis is performed through the Visual Stability Intervals output. This output determines in detail the impact of a change in the weights of the criteria. It shows how the value of the global flow ϕ modifies according to the weight of each criterion and is complementary to the previous model, which allows manual weight variation. This graph allows us to visualize an approximation of how suppliers behave by changing the weights of each criterion. It also reveals the same conclusions obtained in Walking Weight, but in a more comprehensive way. Thus, it is concluded that the cost is a very sensitive criterion to the weight variation, being the supplier 3 the most benefited with the increment of the weight attributed to this criterion. On the other hand, an increase in the weight attributed to quality benefits the supplier 10 since it is the criterion that, by contributing about 30% to the final decision, is the one in which this supplier qualifies best.

Figure 9. PROMETHEE GAIA with the criterion axis "quality of material" evidenced
(Source: PROMETHEE-GAIA software)

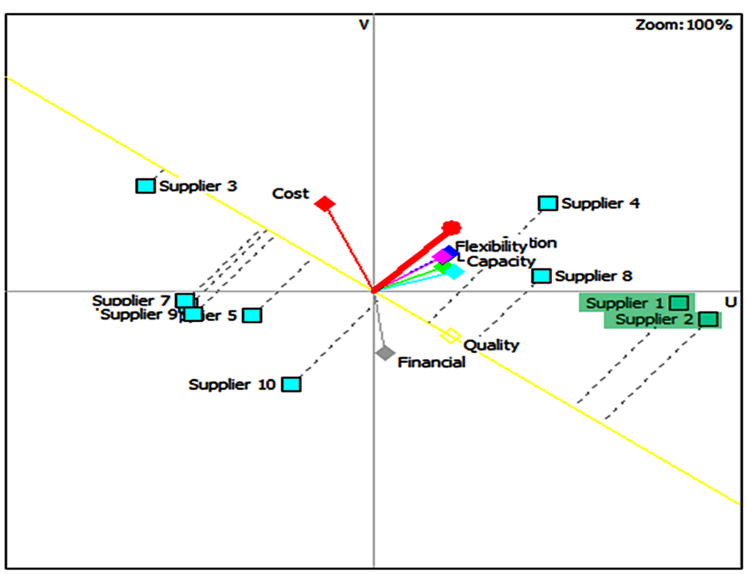


Figure 10. Visual stability intervals for the acquisition cost criterion
(Source: PROMETHEE-GAIA software)

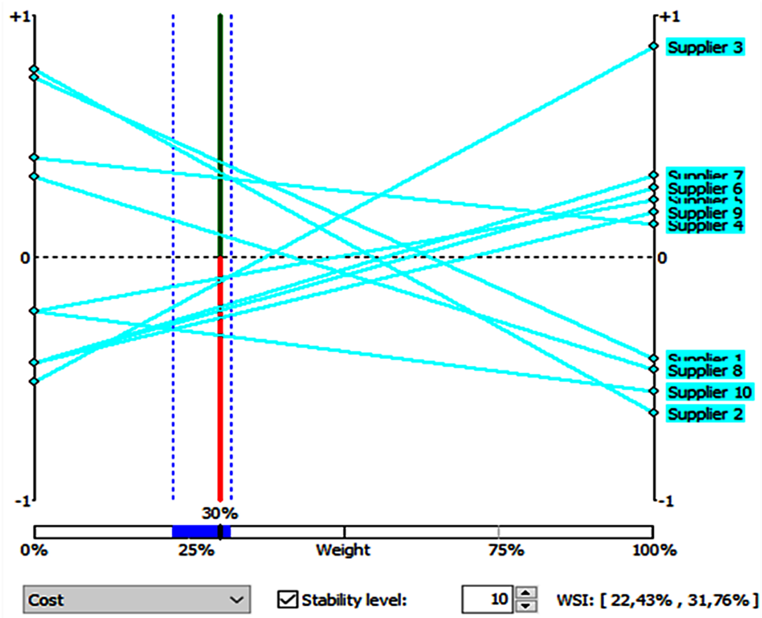
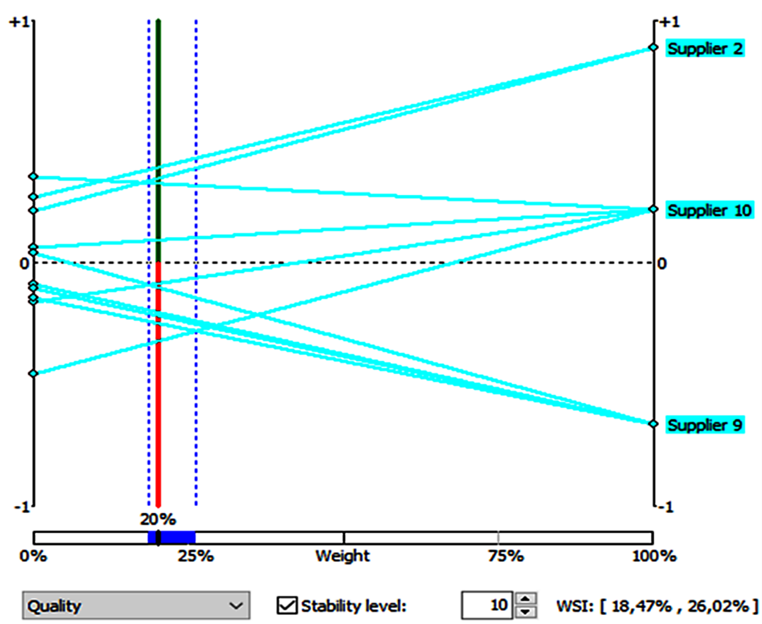


Figure 11. Visual stability intervals for the quality of material criterion
(Source: PROMETHEE-GAIA software)



Finally, flexibility in anticipation of deliveries, certification by suppliers, and logistic lead time are the three criteria that most contribute to the stability of the ranking, while cost and quality are the criteria that provide some instability when re-weighting the assigned weights.

CONCLUSION

The need to establish a good relationship and build trust between a company and its suppliers is becoming increasingly important to make it more competitive in the market, differentiating itself from its competitors. Given the diversity of quantitative and qualitative criteria, as well as the number of suppliers to consider, the evaluation and selection of suppliers becomes more complex. Unlike the traditional approach, where cost alone would determine suppliers' ranking, methodologies that address different aspects show that, although a supplier may have a highly competitive acquisition cost, when compared to others, it does not establish your preference.

With the application of both methods, AHP and PROMETHEE, the intention is to help the CAN company, not to find an optimal solution, but to find the alternatives that best suit the requirements and needs of the company.

Analysing both methods applied to the problem of selection of suppliers for the raw material tinplate in the CAN company, it is possible to obtain a clear conclusion that the supplier 1 is the one that meets the best conditions of supply, taking into account the criteria defined for the process. Still for both methods, as second option is the supplier 2.

Considering the AHP method, supplier 3 appears in third place, in the PROMETHEE method, occupying the sixth place, descending three positions in the ranking. Consequently, suppliers 4, 8 and 5, which, being soon in the positions below the supplier 3 in the AHP method, when in the PROMETHEE method the supplier 3 occupies the sixth place in the ranking, the suppliers 4, 8 and 5 move up one position each. These small differences can be explained by the fact that the weights used are distinct and interpreted differently.

The AHP method, by allowing formal structure of the problem, taking into account experiences and perceptions in a logical way, making it possible to perform priority or weight scales, proves to be very advantageous in the analysis (T. L. Saaty, 1990). On the other hand, this method is based on the selection and preferences of decision makers who, being subjective, have a considerable influence on the results (Ayağ, 2005).

On the other hand, as for the PROMETHEE method, the obtained ranking can be manipulated according to the preferences of the decision maker. That is, depending on the preferences of the agents responsible for decision making, how the weights are assigned will have a great impact and will determine the ranking obtained, not being anything linear. The way the weights are assigned creates a major impact and reshapes the entire ranking, subject to oscillations in results and ranking of suppliers. However, PROMETHEE-GAIA software that uses this method, by providing a variety of outputs, is extremely advantageous and allows the decision maker, depending on the analysis he wants, to have different results to re-evaluate and compare different scenarios.

Through the results presented, it is verified that the suppliers 1 and 2 are more appealing, according to the proposed criteria. Both suppliers have a high quality in the product, a reduced lead time, a greater capacity to meet the company's volume requirements, are governed by the European standard (considered the most appropriate by the CAN company), have flexibility in the face of unforeseen, as well as excellent financial stability. The only criterion that these suppliers distance themselves from the requirements of the company is the cost, having a weight for decision making of 30%. This means that although the heavier criterion is less favourable to the supplier, it stands out from the rest when evaluating all criteria and all suppliers. In short, the cost that a priori would classify the ranking of suppliers, does not guarantee the best selection, reinforcing the need to consider other aspects.

In terms of future work, it would be interesting to extend these methodologies to other raw materials that the company consumes from other suppliers. The proposed method can also be extended to constitute a tool that allows the professionals of the purchasing department of the CAN company to evaluate and select the suppliers in a fast and objective way.

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