Multi-criteria Model for Classifying Clients of Companies Distributing Liquefied Petroleum Gas

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Abstract

Liquefied Petroleum Gas (LPG) is a fossil fuel that has been attracting a lot of attention in national and global markets because of its logistical versatility, its calorific power, and because it emits a low level of pollutants. The history of its exploitation in the sharply competitive Brazilian market has been marked by various crises which made the exploitation of LPG an activity that has been subject to a number of uncertainties. The product is in the production chain of different market segments and is an important component in the national energy matrix. As a result of this, the process of classifying consumers by LPG distributors is a strategic task and subject to a set of criteria that need to be observed. In this context, this article concentrates on multi-criteria modeling in order to resolve the problematic of classifying clients in a LPG distribution company. A model is proposed based on the ELECTRE TRI method and the aim is to allocate the portfolio of clients to a set of ranked classes.

Keywords: Multi-criteria Decision Aid, Liquefied Petroleum Gas, ELECTRE TRI, Classification of clients, Distributor of Liquefied Petroleum Gas

Introduction

Liquefied Petroleum Gas (LPG) is considered an important consumable for modern life, by fulfilling at one and the same time both a social function and that of maintaining the production infrastructure in several nations.

In Brazil, the market is operated by distributors that are accredited by the National Petroleum Agency. As a result of the high costs of facilities and the production structure, both at the national and global level, the degree of concentration of this market is very high.

As there is a variety of clients, the distributor needs to establish categories that may be of help in rendering the due service and in correctly operating each segment of the market. It was by following this line of reasoning that most distributors

in Brazil opted to mirror the external segmentation of the market in internal classes.

Over the last ten years or so, there has been a sharp decline in LPG´s share in the Brazilian energy matrix. One of the main reasons for this reduction is related to the rate at which LPG has been replaced by other fuels. Besides this high replacement rate, the market concentration itself prevailing in Brazil creates real trade wars among distributors who seek to maintain their portfolio of clients and expand their market share at the cost of drawing clients away from competitors which makes the task of commercial management one of the keys to survival in the industry.

To manage the portfolio of clients, distributors are used to establishing classes that reflect the market. These classes can be designed taking different requirements into consideration that vary from the level of importance of these clients for the company to the main economic activity of the consumer.

The large problem in this type of procedure is that, when deciding into which class the alternative should be allocated, the decision-maker should consider a set of criteria that, without an adequate approach, will be ignored in practice.

The clients of these distributors vary because of their consumption, their profitability, their vulnerability regarding other forms of energy and intermittence and the type of supply. All these factors need to be weighted at the time of classification, since the structure of commercial and production service is based on the class of this client. Undue allocations decrease the distributor's distribution response time vis-à-vis the actions of competitors, set undue prices for the segment and increase the costs of distribution. Moreover, the whole of production planning by the distributor is mounted as a result of how it has compiled its clients into classes.

Putting forward a multi-criteria method for allocating clients to these classes is something that is brand new for Liquefied Petroleum Gas distributors in Brazil and will aid them in distributing (production, commercial and human) resources throughout their company, which will have positive repercussions when they implement their strategies.

This study sets out to put forward a multicriteria decision model to tackle the problematics of classification, in order to allocate clients into ranked classes, according to their level of importance, which are aligned with the Strategic Plan of the company under study. To do this, it is necessary to propose a new standard of categories for classifying clients. These categories should, in the light of criteria defined by the decision-maker, be homogeneous enough so that the company can provide services in accordance with an organizational structure already set up, and in addition to verifying the consistency of results, together with the decision-maker, after applying the algorithm of the method chosen.

Research Method

In order to construct and apply the model, a review of the issue was undertaken and the problem modeled. Next, by means of two interviews with the

decision-makers of the specific distributor, the current functioning and the process of classifying clients was identified. As the clients chosen were from two different areas and consequently managed by two different people, it was agreed that only the manager of the metropolitan area would participate in the process.

In order to define the alternatives, a set of 40 clients chosen at random by the company was compiled. This came about because of the extremely competitive environment which the distributor is in, which makes any information about the client base extremely confidential.

Then the criteria were defined in accordance with the objectives contained in the 2008-2018 Strategic Plan of the company under study, using as a base some training events and internal manuals.

Having obtained the alternatives and the judgment criteria, the method to be applied was defined, while noting the characteristics of the problem and the decision maker.

One of the points highlighted by the decision-maker and one that was achieved in this study was the need to maintain the same number of classes that the company already works with today. As the method chosen was ELECTRE TRI, there was a need to define the thresholds of preference and indifference of the model, together with the cut-off limit. The algorithm was calculated using a specific software program.

After the results, the classification model was presented to the decision-maker who checked the allocation of the alternatives to the classes and he validated the results positively and recommended its application to other regions where the company operates.

Support to Multi-Criteria Decision-Making

Support to the decision is the activity of the person who, by using models explicitly, but not necessarily in a completely formalized way, assists in obtaining elements which may answer the questions posed by a stakeholder in a decision-making process. These elements work to clarify the decision and usually lead it to a recommendation (Roy, 1996).

Problems related to decision making are common in a multitude of areas, both public and private ones, and, since time immemorial, people have been trying to resolve them based on abstractions, heuristics and deductive reasoning in order to guide and validate their choices (Gomes *et al.*, 2004).

For Almeida and Costa (2003), multi-criteria aid for decision-making is in principle to seek to establish a relationship of (subjective) preferences between the alternatives which are being evaluated under the influence of several criteria, in the decision-making process.

Several methods have been put forward for tackling problems involving

the classification of alternatives. Among these methods are ELECTRE TRI (Roy, 1996), N-Tomic and UTADIS (Doumpos and Zopoundis, 2004). In this article, the option was made to use the ELECTRE TRI method, the justification for which will be presented later.

ELECTRE TRI is an outranking method from the ELECTRE (*Elimination and Choice Translating Algorithm*). These methods are based on building an outranking relationship that includes the preferences set by the decision-maker vis-à-vis the alternatives and existing criteria (Roy, 1996)

The ELECTRE TRI method is targeted on problems, the problematic of which is classification (Roy, 1996). According to Belton and Stewart (2002), the original procedure was conceived so as to allocate the alternative to one of the three alternatives: acceptable, unacceptable or indeterminate. They also state that the method was extended for use in classification problems with more than three different categories.

According to Doumpos and Zopoundis (2004) the objective of ELECTRE TRI is allocate a discrete set of alternatives $A=\{x_1, x_2,.., x_m\}$ in q groups C_1, C_2, ..., C_q. Each alternative x_j is regarded as a vector $g_j=\{g_{j1}, g_{j2},..., g_{jn}\}$ consisting of the performance of the alternative x_j on the set of criteria evaluated g.

Contrary to the classical procedures based on sum of weights (which presents the possibility of compensation), the ELECTRE TRI procedures reject this possibility and offer a process of comparison among the references. Further and more detailed discussions on ELECTRE TRI can be found in Roy (1996), Mousseau *et al.* (2002), Dias *et al.* (2002) and Gomes *et al.* (2004).

Contextualing the Problem

Liquefied Petroleum Gas (LPG) is a non-renewable fossil gas, which remains in a liquid state at moderate pressures. It can be obtained by processing Natural Gas or through refining crude petroleum.

LPG in Brazil is used in various sectors of the economy. Four consumer segments in Brazil can be identified: residential, commercial, industrial and cattle-raising.

Although widely used worldwide as a fuel for vehicles, Brazilian legislation prohibits the use of LPG in any type of vehicle, except forklift trucks. Technically there is no restriction on using liquefied gas in combustion engines. In fact this restriction stems from the measures taken by Brazil to limit shortages of supply at the time of the Gulf War in 1991 and it is these which persist today. Thus, we cannot identify the automobile sector as a consumer of LPG but rather LPG is inserted in the industrial sector.

- Residential - The most common way of marketing LPG to this market is in a concentrated form in 13 Kg cylinders which are intended only for

residential use, and correspond to about 70% of total sales of the product.

- Commercial - In the Commercial area, LPG has found extensive applications. In bars, restaurants and industrial kitchens it is used when preparing food, heating water and washing utensils. In hotels it is also used for heating water, in air-conditioning and insect control. In laundries, it is used when drying clothes, and in laboratories and hospitals, it is applied when disinfecting and sterilizing objects, in air conditioning systems and when incinerating contaminant waste.

- Industrial – In steel-mills, LP gas is used for heating the furnaces because it provides a more homogeneous thermal process. Also because it helps to control the purity of steel, thanks to the complete combustion of the gas. Moreover, it helps special firing processes. The losses of market imposed by policies for expanding the use of natural gas have led to LPG losing a large space in the steel industry. Nevertheless, the industry responded quickly with technological innovations that made LPG competitive again. The distribution of the consumption of LPG and Natural Gas by industrial sub-sector shows similarities. Both forms of energy are most used in the areas of food and beverages, ceramics, iron, and steel. Nevertheless, Natural Gas has been increasing its share in this sector of the economy.

- Agrobusiness - Although Brazil has a negligible share (less than 1% of total consumption), LPG has a wide application in agro-business worldwide which creates huge opportunities for selling this product to the agricultural sector. In horticulture, LPG can be used for heating and controlling the temperature of greenhouse plants, flowers and fruit. In the poultry segment, it is used in the supply of gas to the cloches that radiate heat, thus facilitating the rapid growth of birds and preventing lung diseases. It is also used to supply the flame-thrower used to sterilize and clean hen-houses. Finally, it is used to dry and roast grains and seeds.

The company that is object of study in this article groups its clients into four different classes and uses the nature of their operation as a criterion.

The first group refers to household consumption where the product is sold to a representative who in turn undertakes the retail distribution.

The second group refers to the consumption of gas through a channel deemed as Mixed Delivery. Included in this class are industries, shops and condominiums that use transportable cylinders weighing over 13 kilos (cylinders of 20 and 45 kilos).

In the third group are the condominiums that have piped gas installations and stationary tanks which are supplied by small bulk truck.

Finally, in the fourth group we have the industries that, depending on their storage tanks, may be supplied by small or large bulk trucks. In some regions of Brazil, the company also has a fifth segment called major clients, which manages all industrial consumers with large storage tanks.

In strategic terms the company has established a level of importance for each category, according to its strategic planning.

As the corporate structure for exploiting this market has already been formed, in the modeling that will be presented below, the formation of five classes of clients, mirroring the current classes, was considered. Thus the implementation of the model does not necessarily imply redesigning the company's organizational structure.

Model for Classifying Clients

Aspects or Inconsistencies to Be Corrected in the Current Model

Despite reflecting the segmentation of the market, the current model causes some difficulties in the process of managing clients. This is because each market has a distinctive feature, but not all components of this market are homogeneous.

The area of refillable domestic containers is characterized by intense competition and the need for constant monitoring of prices. Visits to clients, conducted by consultants, should be of high frequency so as to detect any action of competitor distributors and to take corrective strategic actions.

However, the bulk domestic market is more differentiated in that it has a more comfortable profit margin and one that is counter-balanced by low consumption by each client.

The commercial segment is operated in part by the area of refilling and in part by the area of bulk. All clients who consume the products in transportable cylinders are more vulnerable to attack from the competition since it is simpler to buy a cylinder from of another similar company. Yet supplying a company on its industrial premises when it is supplied by a competitor is prohibited by law which means that the process of changing supplier is more complex.

In the industrial area and that of major clients, as the relationship is governed by strict contracts, the main focus is on the level of supply and also on avoiding any failure in supply. This happens because industries are usually located in more distant regions, which demands more from the logistical structure of distribution, the maintenance of levels of safe stocks on clients' premises and normally any stoppage time occasioned by lack of the product may be converted into a financial penalty for the Distributor. Table 1 shows the generic characteristics of each market segment.

Table 1 – Comparison between LPG Market Segments.

Segment	Storage level	Visits	Profitability	Number of Clients
Representatives	Low	High frequency	Average	High
Condominiums	Low	High frequency	Average	High
Commerce	Average	Average	High	Average
Industries	High	Average	High	Average
Agro-business	High	Average	High	Low

It can be seen that for each segment there is a different kind of service that is a combination of consultants' visits, attacks by the competition, profit margin and volume. Nevertheless, the main focus of competition to act on a client is still on its volume consumed and the measured profit margin.

Clients who are most exposed to attacks from the competition and who have a high level of profitability require particular attention by means of renegotiating prices, granting longer payment terms, piping specific mixtures (richer in propane), and so forth. However the current model leads to clients such as condominiums with high levels of storage not receiving the due attention, because in this case there was a general classification of the segment and one that does not reflect their real consumption.

Treating customers equally in heterogeneous classes has already caused the loss of some strategic consumers. To solve this problem the company created a fifth class for exploiting the market called Major Clients, but it has still not managed to solve all the problems related to undue classification. This is because clients who do not high levels of storage, and who consume an average volume of gas and record a large contribution to the margin do not have the same the requirements as major customers despite being equally profitable when compared to a consumer classified as a major client. Further, it will continue to receive the treatment of the class into which it has been put.

The creation of more homogeneous classes will help the decision-maker in the process of serving clients and allocating human resources for managing this, thus reflecting more solidly the Company's strategic objectives.

The adoption of a multi-criteria methodology will allow the creation of these classes and the allocation of alternatives, while respecting the criteria specified by the decision-maker. This is justified by the difficulty that the decision-maker faces when looking at criteria that conflict with each other and contain many pieces of information, which are often impossible to take into account at one and the same time.

In order to make the correct classification, it is essential that there is a set of criteria that are aligned with both the company's long-term strategies but which also provide sufficient information for the creation of more homogeneous classes in order to unify the distributor's strategic actions.

Criteria

A set of criteria that are considered at the time of making decisions was identified and which will be entered into the model.

Gathering these criteria used two of the distributors' internal manuals and three commercial training sessions which indicated which aspects should be observed to classify an industrial consumer in the category of Major Clients (criteria for storage, unitary profit margin, vulnerability of supply and type of supply).

The criterion related to intermittency of supply was suggested by the

decision-maker in order to incorporate information into the model on the degree of dependence that the consumer has on the distributor, and the risk regarding contracts with penalties for failing to supply the product on time.

The decision-maker considered it fitting to extend these criteria to the model by setting for them a scale of importance from the largest to the smallest, and one that reflects his individual goals, as follows:

a) Tank storage: the client's storage capacity reflects its consumption. There may be customers with a high tank storage independently of the segment in which it operates. The sales volume also directly influences the distributor's market share, thus making high-volume customers important for carrying out the company's strategic planning.

b) Unitary Profit Margin: many contracts have been negotiated on the basis of a lower volume, but balanced by a much higher margin. This criterion reflects the unitary profitability that the product may have. Depending on the negotiation entered into, it is possible to create groups of consumers with a high unitary profitability, even if some have low consumption.

c) Type of Supply: shall be defined three types of supplies will be defined: the first is domestic refilling, the second considers commercial refilling and the third supply *in loco*.

d) Vulnerability of the Client: there are clients who are more vulnerable than is commonly found. This very often occurs because the contractual links are not robust, as they offer more freedom to the client to replace the distributor. This concentration arises mainly when the consumer uses transportable cylinders, but which may be extended to other segments. There are also cases where the user segment is experiencing heavy harassment from other fuels such as happens when an industry that is going about replacing its energy matrix with natural gas.

e) Intermittence of supply: many industries have a need for an intense form of supply, without running the risk of a shortage of the product on pain of their production being adversely affected, thus requiring more from the distributor's logistics operations. Other industries, however, have LPG only as a backup source of energy, since they use other sources such as Natural Gas. The same happens in other segments where competition is so intense that any lack of product is reflected as a reduction in the company's market share.

These criteria will be used as a basis to perform the classification of alternatives, as demonstrated in the next item.

Justification for Choosing the ELECTRE TRI Method

The methods of the French School of Multi-criteria Decision Aid were developed in counterpoint to the methods of the American School, in order to offer a

more flexible resolution of the problem, since they do not presuppose the necessary comparison between the alternatives and exempt the analyst from conducting a hierarchical structuring of the existing criteria. This makes the task of structuring and settling by the European methods very much simpler.

In particular, the application of ELECTRE is due to the fact that this method incorporates a concept of models of preferences that besides the situation of strict preference and indifference includes weak preference and incomparability, this providing a more realistic representation of the problem and exempting the decision-maker from making the wrong choices.

For the problem proposed, complete comparability becomes inadequate because of the very characteristic of the alternatives, which may offer information that is not precise, besides there being a possibility that such information is not complete and exhaustive. As pointed out in previous items, the alternatives may be so diverse that what is required from the decision-maker are specific pieces of information that are not always available. One example of this occurs when the alternatives are analyzed under the criterion of vulnerability of the clients vis-à-vis attacks from competitor sources of energy or distributors, where it can be clearly recognized that there are not enough items of information for the decision-maker to declare clearly and incontestably his or her preference or indifference regarding the main alternatives.

The incomparability occurs when the decision-maker has not managed to obtain sufficient information to define the values of the alternatives being evaluated. One example of this is when it is not possible to obtain data about the unitary profit margin for customers who buy LPG in transportable cylinders. There are intense price fluctuations in these markets, and very often, the decision-maker is not able to determine what his real profit margin because this information is not available or it is determined by the price offered by the competition in the act the sale. In classical Decision Theory, this case would be classified as indifference, which may oblige the decision-maker to issue an opinion that does not reflect the reality of the facts.

There are industries that need an uninterrupted supply, while others use LPG only as backup. Others lie at a half-way point that does not have clear boundaries. In these cases, it is clear there are Pseudocriteria which require the determination of thresholds of preference *(p)* and indifference *(q),* which can then be considered as limits of tolerance for the establishment of strict preference (large industries that cannot tolerate shortages of the product) and indifference (industries that use energy as a backup). Every alternative that will provide a superior performance to the threshold of preference, will demonstrate that the need to pay close attention to supply is imperative in this criterion.

The fact of ELECTRE being a non-compensatory method favors more aligned results, since there are inevitably alternatives that will have a low performance in some criteria and which have a good performance in others, such as clients of the domestic market whose performance is weak in criteria for tank storage and vulnerability and a good performance in others.

In the distributor, the current method of classifying clients uses a set of classes that serve as the standard, where the difficulty lies precisely in the adherence of the alternatives to these classes, since separation was made on the basis of their economic activity.

As this is a problem where there is a need to classify alternatives, ELECTRE TRI was chosen because it performs this classification by means of comparing each alternative with a stable reference. These reference alternatives are fictitious and used to bound the categories where the real alternatives will be classified. The distributor, therefore, has the freedom to define these reference alternatives, thus creating classes that attract alternatives with more adherence.

Finally there is the fact of ELECTRE TRI having been conceived to deal with actions in ranked categories. Thus it is possible to classify a set of actions according to pre-defined and ranked categories based on multiple criteria. This is in line with the distributor's interest to establish an order of classes according to their degree of importance to the company's strategic objectives.

Importance of Classifying Clients Strategically

The company is located in an extremely competitive and highly mature market. This competition may be divided into two types: internal and external. The internal one refers to the commercial war waged between the various distributors that operate in the same geographical region or exploit the same market. The rate of growth of many markets is so low that any increase in the market share of a company may be translated into a reduction of the share of another company.

In markets where price sensitivity is high, it does not become attractive to highlight aspects other than the value of the product. In the same way, in markets where the priority is the non-interruption of the service care, it makes no sense to emphasize the price factor.

External competition is in markets where LPG has shown high rates of being substituted by other forms of energy. This is currently occurring in the domestic market, where there is a high rate of the product being replaced by fire-wood and in the industrial area where substitution is occurring because of the expansion of natural gas.

The company has presented plans to increase its share in all these markets, but so that it can respond correctly to each situation, it is imperative that the classes are defined adequately. The design of these classes will help the company's strategic targeting. It will also be possible to establish a level of importance of these classes, by exploring areas that the company considers strategic, such as in the case of clients who have high tank storage.

Finally there is the possibility of directing a more concentrated effort on activities that exploit the potential of clients, adequately as to their class.

Aplication of the Model Proposed

This item describes the steps for applying the method chosen and the phases of eliciting the parameters of ELECTRE TRI. Then, there will be a discussion of the results class by class to evaluate the validity of the results obtained.

Phases of the Application

According to Mousseau *et al.* (2002), ELECTRE TRI combines the alternatives into various categories, following two consecutive steps. The first consists of building an outranking relationship S, which is characterized by the analysis of these alternatives on the reference alternatives offered. The second phase deals with the exploitation of this relationship.

In order to apply the method, it is necessary that the phases which were proposed by Roy (1996) are followed and completed. Analyses of robustness will be undertaken under the results, with the objective of verifying the consistency of the data regarding the results offered by the method.

Set of Alternatives

As the company has national coverage and its volume of customers is extremely high, in order to apply the model a group of clients was chosen who were located in the Metropolitan Region of Recife and in the Industrial Complex of Suape in the State of Pernambuco. In all, thirty clients were included in the study. They are all currently classified according to their model of economic activity (domestic, commercial, industrial, agro-business and major clients).

Customers who are located in more distant regions such as in the interior of the State of Pernambuco, but whose headquarters are in one of the regions of study were also considered.

Given that the data on the location and segmentation of clients are confidential, in order to demonstrate the method, a set of alternatives was chosen which uses the following ratio of clients: 10 domestic clients, 10 from the commercial area, 11 from the area of industry, 4 from agro-business and 5 major ones.

The distributor, for strategic reasons, also chose not to publish its portfolio of clients. Therefore, rubrics were used to designate the alternatives using the pattern $A_1, A_2,..., A_n$. The alternatives and their current classifications are described in Table 2.

In order to judge the alternatives, a scale was used that ranged from 0 to 100, where the decision-makers could make the evaluation of their performance in the light of a set of criteria.

Table 2 – Register of the Alternatives

Alternative	Current Segment	Alternative	Current Segment	Alternative	Current Segment	Alternative	Current Segment
A_1	Domestic	A_{11}	Commerce	A_{21}	Industry	A_{31}	Industry
A_2	Domestic	A_{12}	Commerce	A_{22}	Industry	A_{32}	Agriculture
A_3	Domestic	A_{13}	Commerce	A_{23}	Industry	A_{33}	Agriculture
A_4	Domestic	A_{14}	Commerce	A_{24}	Industry	A_{34}	Agriculture
A_5	Domestic	A_{15}	Commerce	A_{25}	Industry	A_{35}	Agriculture
A_6	Domestic	A_{16}	Commerce	A_{26}	Industry	A_{36}	Maj. Clients
A_7	Domestic	A_{17}	Commerce	A_{27}	Industry	A_{37}	Maj. Clients
A_8	Domestic	A_{18}	Commerce	A_{28}	Industry	A_{38}	Maj. Clients
A_9	Domestic	A_{19}	Commerce	A_{29}	Industry	A_{39}	Maj. Clients
A_{10}	Domestic	A_{20}	Commerce	A_{30}	Industry	A_{40}	Maj. Clients

Elicitation of Parameters for the Model

The algorithm requires the decision-maker to feed in some information about the thresholds p_i, q_i and v_i and the cut-off limit (λ).

The phase of eliciting weights is considered one of the most delicate points in modeling the problem. This is because it is very often difficult to measure which level and what level of importance each criterion has. The thresholds and the cut-off level are also critical since very often the decision-maker does not have a real notion on these values, and does not feel comfortable about expressing an opinion.

Weights

The company defined in its Strategic Planning that it aimed to the leader and most profitable distributor in the market. Therefore, in determining the weights, the decision-maker opted for establishing classes of importance which group clients that are aligned with these goals.

Although this stage is considered critical by many researchers, the decision-maker felt no difficulty about determining the values of each criterion, since they had already been defined as they took the company's long-term goals into account. That is, the decision-maker chosen to prioritize the criteria that could provide a sharper degree of leverage on the company's strategies (Table 3).

Reflecting this line of reasoning the decision-maker attributed a weight of four to the two criteria that may impact more heavily on the distributor's results (ACT and MCU). Then a weight of three was attributed to assess the level of the client's vulnerability (VCL). This case demonstrates the concern to direct more attention towards clients who are more susceptible to being harried by the competition or other forms of energy. The most harried clients might well be classified in higher categories.

Table 3 – Table of Weights of Criteria

CRITÉRION	ACRONYM	WEIGHT
Tank storage	TCA	4
Unitary Contribution to Margin	MCU	4
Vulnerability of the Client	VCL	3
Intermittence of Supply	IAB	3
Type of Supply	TAB	1

The robustness of the contractual relations (IAB) also received a value of weight 3, thus showing that clients who will require most logistical effort in terms of supply should be categorized in a more important way than the others. Finally, the type of supply (TAB) is given a weight of one. This criterion demonstrates that the influence of the mode of supply is much lower when compared to the other criteria. For the decision-maker, although the type of supply may influence the decision, it should have less influence, when compared to the other criteria.

Scale of Judgment

In order to judge the criteria, a nominal scale associated with a numerical scale was laid down. This occurred because there were subjective criteria in the evaluation. The scale adopted is presented in Tables 4, 5, 6 and 7. They enable the decision-maker to judge the importance of the criterion using a verbal language.

Table 4 – Scale of Judgment for the criterion TCA

Verbal Scale	Numerical Value
>10 tonnes	5
10 tonnes	4
5 tonnes	3
1 tonne	2
< 1 tonne	1

Table 5 – Scale of Judgment for the criterion MCU

Verbal Scale	Numeric Value
>50 %	5
50 %	4
40 %	3
20 %	2
10 %	1

Table 6 – Scale of Judgment for the criteria VCL and IAB

Verbal Scale	Numeric Value
Very High	5
High	4
Average	3
Low	2
Very Low	1

Table 7 – Scale of Judgment for the criterion TAB

Verbal Scale	Numeric Value
Bulk VGG	5
Bulk VPG	4
Bulk VPG and Mixed	3
Only Mixed	2
Re-fillables	1

Categories

In ELECTRE TRI, a set of actions, which in this case may be considered the clients, was evaluated under the five criteria set out by the decision-maker. As the company already has all of the organizational structure designed to work with five classes, the decision-maker opted to keep the same number of categories considered in ELECTRE TRI, which were named in order of preference as per Table 8.

Table 8 – Categories

CATEGORY	RUBRIC
Clients Class 1	CLS1
Clients Class 2	CLS2
Clients Class 3	CLS3
Clients Class 4	CLS4
Clients Class 5	CLS5

Each of the categories will be bounded by two reference actions, such that bh marks the top of the category, while bh-1 marks the bottom of the category, as proposed by Roy (1996) who states this is necessary to establish the reference actions b0, b1 ,..., bk such that, except for the first and last category each, simultaneously, forms both the upper limit of one category and the lower limit of another category, bk being in all criteria the worst one for one category and the best one the other one immediately beneath it.

An interaction was conducted to try to define the classes. However, it was observed that very high values in the categories TCA and MCU left CLS1 without any client attributed to it. The values of these classes were adjusted by redefining the following category limits (Table 9 and Figure 1).

Table 9 – Limits of the Categories

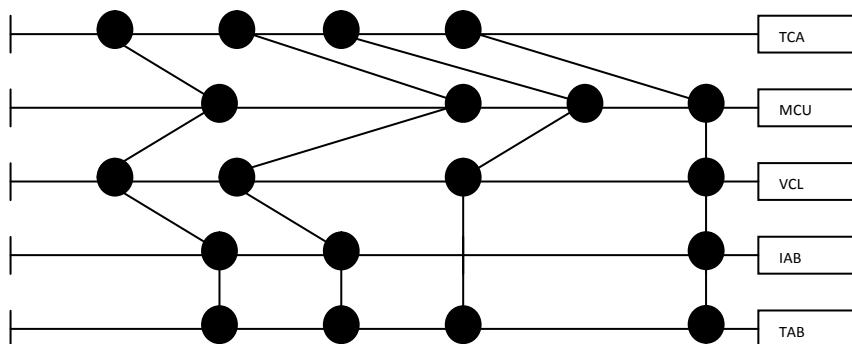| REFERENCE ALTERNATIVES	LIMIT OF THE CATEGORIES				
	TCA	MCU	VCL	IAB	TAB
B_1	3	3	3	3	2
B_2	2	2	2	2.5	1.5
B_3	1.5	1.5	1	2	1
B_4	1	1	0.5	1	0.5

Figure 1 – Graphical representation of the limits of the categories

In the two criteria that the company established as the most important (TCA and MCU) the category limits were very rigid, with the objective of only allowing that customers with high levels of tank storage and profits outrank the reference alternatives of CLS1. The area of refillables is considered the lowest of the TAB category, but there is the possibility that there are clients that combine high storage tank capacity and high profitability, but who receive the product by means of transportable cylinders. The option was made to attribute a limit of category 2 to Class 1.

Cut-off Limit

The evaluation of the actions is based on the concept of outranking, where we can state that an action an action a_n outranks a reference action b_h ($a_n S\ b_h$) when there are sufficient arguments to sustain that a_n is not less than b_h. In the model an index of credibility of the relation ($a_n S\ b_h$) is defined that meets the weight of the criteria that support that conclusion and the strength of discordance, by comparing these values to a cut-off limit λ.

As the cut-off limit (λ) is the lowest value of the degree of credibility $\sigma s(a,b)$, which allows it to be stated that *a* is superior to *b*, it is necessary to establish a level that is between 0.5 and 1. Thus, values higher than λ characterize the decisions in which it is sought to minimize the different uncertainties, and the incompatibility relationship between the alternatives could be more frequent, if the other conditions of the problem remain unchanged. Should the option be made for a more reduced λ, the risk of increasing the relations of uncertainty is run. In order to use this method, it was defined that the cut-off limit would be from 0.65, with a view to minimizing the frequency of the relations of indifference and of working with high levels of incomparability

Thresholds

The preferences for each criterion are defined by means of a pseudo-criterion, in which the thresholds of preference and indifference $p_j[g(b_h)]$ and $q_j[g(b_h)]$ consist of intra-criteria information. Thus $q_j[g(b_h)]$ specifies the largest difference between the real alternative and the reference alternative that preserves the indifference between a and b_h in the criterion c. Now, $p_j[g(b_h)]$ represents the smallest difference

between the alternatives a e b_h in the criterion g_j compatible with a preference of a on this criterion.

According to Miranda and Almeida (2003), the structure of preferences with pseudo-criteria – a model with a double threshold $p_j[g(b_h)]$ e $q_j[g(b_h)]$, avoids the sudden transition between indifference and strict preference, there being a zone of hesitation represented by the weak preference.

The thresholds of preference and indifference were defined as per Table 10:

Table 10 – Limits of the Categories

	q		Q		p		p
TCA	1	IAB	1	TCA	3	IAB	3
MCU	1	TAB	1	MCU	3	TAB	3
VCL	1			VCL	3		

As these values were arbitrated, a sensitivity analysis will be conducted so as to observe the influence of their variation on the optimistic and pessimistic procedures of the algorithm of ELECTRE TRI.

Application of the Method

The decision-maker issued, based on the verbal scale, the judgment of the alternatives in the light of the five criteria, as can be verified in Appendix 1. The information obtained from the decision-maker was converted into normalized scales that vary in ascending order from 1 to 5, as explained in the previous items.

The algorithm of ELECTRE TRI both in its optimistic and pessimistic versions displayed the same results, showing that under these perspectives, the parameters responded positively as they offered the same results. Based on the cut-off limit with 0.65, the preference threshold of 3 and that of indifference of 1, ignoring the veto threshold, the results presented in Appendix 2 were obtained.

Discussion of the Results

After using ELECTRE, a very sharp change was verified in the patterns of classes in relation to the previous procedure. As the company has already classified its customers into categories with varied levels of importance, we can observe the following generic transfer of the old categories with regard to the new ones (Table 11).

Table 11 – Repositioning of the Categories

Level of Importance	Old Category	New Category
1	Major Clients	CLS1
2	Industries	CLS2
3	Agro-business	CLS3
4	Commerce	CLS4
5	Domestic	CLS5

The final allocation of the classes is shown in Figure 2.

CLS1	CLS2	CLS3	CLS4	CLS5
$A_{15}; A_{16}$	$A_1; A_3$	$A_2; A_5$	$A_4; A_6$	$A_{10}; A_{17}$
$A_{23}; A_{24}$	$A_{26}; A_{32}$	$A_{12}; A_{14}$	$A_7; A_8$	$A_{18}; A_{19}$
$A_{25}; A_{38}$	$A_{36}; A_{37}$	$A_{20}; A_{21}$	$A_9; A_{11}$	$A_{28}; A_{33}$
	$A_{39}; A_{40}$	$A_{22}; A_{27}$	$A_{13}; A_{30}$	$A_{34};$
		$A_{29}; A_{31}$		
		$A_{35};$		

Figure 2 – Final classification of ELECTRE TRI

With this method, 33 alternatives were reclassified and 7 remained at the same level The largest class, after the interactions of the algorithm was CLS3, with 11 alternatives and the smallest was CLS1 with 6 alternatives.

One point to be observed positively in the process is that, after the decision-maker put into effect a variation in the cut-off limit from 0.65 to 0.50 (which represented a reduction of 23%), he perceived an acceptable variation in the final classification. Of the 40 alternatives that were part of the set, 11 were reclassified because of the alteration, i.e. approximately 27% were reallocated due to the greater tolerance to indifference relationships. These grew from 81 to 93 cases.

The results of the first interaction, when λ was considered greater provided, according to the decision-maker, results that were more aligned with his expectations, besides not showing any relationship of indifference. Given that decision-makers work with scenarios that very often do not offer sufficient information, it is preferable to minimize the relationships of indifference for the sake of comparability, which in both cases did not occur.

The characteristic of ELECTRE not allowing compensation between the criteria shaped a new composition in CLS1 as it accepted only those alternatives that were actually better in all aspects in relation to b_1. Thus, it was possible to switch clients around who were in classes of lesser importance and which did not receive the appropriate strategic treatment.

The former Class 1 comprised five customers, four of whom dropped to CLS2, leaving only one in the same category. This shows that the criterion of tank

storage (the main requirement for classification in CLS1 in the old method) was not enough to keep the alternatives in the first class because, in order to outrank the alternative b_1, what was needed was to have an adequate performance in all the criteria.

On the other hand, the new composition of CLS1 is formed by the alternatives ($A_{15\text{-Commerce}}$, $A_{16\text{-Commerce}}$, $A_{23\text{-Industry}}$, $A_{24\text{-Industry}}$, $A_{25\text{-Industry}}$ and $A_{38\text{-Major Clients}}$). Outstanding examples were the alternatives A_{15} e A_{16} that, because of their results, rose to Class 1 and showed that, due to the heterogeneity of the clients, they were in a lower class.

In CLS2 (A_1, A_3, A_{26}, A_{32}, A_{36}, A_{37}, A_{39}, A_{40}) reduced its size from ten to eight alternatives, with only one such client remaining from the industrial category (A_{26}). This class received four alternatives from the former segment of major clients (A_{36}, A_{37}, A_{39}, A_{40}), one client from Agriculture (A_{32}) and two from the Domestic category (A_1 and A_3).

The most striking change was in the segmentation of the domestic category, since, under the previous method, the alternatives A_1 and A_3 were allocated to the lowest class. Because they showed sufficient strength to outrank the reference alternative b_2, it was possible to migrate to CLS2. This demonstrates the heterogeneity of the classes and how these clients were undersized.

The largest class constructed by the ELECTRE algorithm is the CLS3 ($A_{2\text{-Domestic}}$, $A_{5\text{-Domestic}}$, $A_{12\text{-Commmerce}}$, $A_{14\text{-Commerce}}$, $A_{20\text{-Commerce}}$, $A_{21\text{-Industry}}$, $A_{22\text{-Industry}}$, $A_{27\text{-Industry}}$, $A_{29\text{-Industry}}$, $A_{31\text{-Industry}}$, $A_{35\text{-Agirculture}}$) was designed by receiving alternatives from all the old classes with the exception of Major Clients. Only the alternative A_{35} remained from the former classification, while the other ten came from the other classes.

CLS4, both because of the optimistic and the pessimistic procedure, was formed mostly from clients of the domestic segment (five alternatives A_4, A_6, A_7, A_8, e A_9), two from commerce (A_{11} and A_{13}) and one from industry (A_{30}). The client from the industrial segment received a lower classification because it uses LPG only as a backup.

The last category (CLS5), which consisted predominantly of clients from the domestic area segment received one client from the industrial area ($A_{28,}$ who uses this form of energy as a backup), three from the commerce area (A_{17}, A_{18} and A_{19}, who use transportable cylinders) and two from the area of agro-business (A_{33} and A_{34}) that is not very big.

An analysis of the application of the model based on the new classes allows it to be inferred that the elicitation of a good number of the parameters of the model occurred in an acceptable manner. In fact, with regard to the weights, the decision-maker spontaneously managed to establish what the level of importance would be that each criterion would receive, since the company's strategies allowed both the establishment of the criteria as well as the weights in a direct and objective way.

The definition of the thresholds was performed adequately. The decision-

maker opted not to apply the threshold of veto, and established, for all criteria, the threshold preference as 3 and that of indifference as 1. A difficulty perceived by the decision-maker was to determine the cut-off threshold. However, given that the decision-maker chose to decrease the occurrence of relations of indifference, a relatively higher value was attributed to λ.

The main problem, which was the process of adhesion of the alternatives to the classes, was resolved by the ELECTRE algorithm. After the interactions of the method it was found that most clients were erroneously classified in undue categories.

Conclusions

This study set out to apply a method of multicriteria decision aid in a distributor of liquefied petroleum gas with a view to putting forward a new process for classifying clients.

With the model proposed more than 82% of the alternatives were reclassified, demonstrating that the previous methodology had not been adequate for handling clients and that the level of heterogeneity between them within the classes was higher than was originally envisaged.

As to CLS1, which is considered strategic by the distributor, it was almost completely redesigned. Previously it was made up of industries with extensive tank storage and in the new methodology it received two customers from the area of commerce.

After evaluating the alternatives, the decision-maker confirmed the results provided by ELECTRE TRI were suited to the strategic actions that the company wishes to target and that, given these new classes, it is possible to design uniform actions for each case, thus reaching the initial objectives of this study.

In ELECTRE TRI, it is necessary that several parameters are defined (reference alternatives, preference thresholds, indifference thresholds, thresholds of veto, weight of the criteria, cut-off level and importance of the criteria). The method requires data from the decision maker that are difficult to measure clearly, and thus require some interactions to verify the robustness of the results in the light of the parameters defined.

Some of the parameters such as the thresholds of preference, indifference and of veto were not difficult for the decision-maker to establish in this study. However the same thing did not happen at the time of defining the cut-off limit since the decision-maker did not initially manage to obtain the real dimension of this index and the repercussion of its value on the final results.

In order to minimize the difficulty and uncertainty when setting these parameters, the adoption of an interactive procedure, such as the one developed by Dias *et al.* in 2002, will be suitable. The procedure consists of establishing restrictions for the interval of values of l of the weights and of the classification limits of the actions.

It is judged that it is relevant to study adaptations so as to use methods with more than one decision-maker, since the segmentation of the market is managed by several area managers and the classification may be more consistent should all of them participate in the decision-making process.

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Appendix 1 - Judgment of the Alternatives

Alternatives	Tank Storage	Margin Contribution	Vulnerability	Intermittence of Supplies	Type of Supply
A_1	< 1 tonne	>50 %	Very High	Very High	Refillable
A_2	< 1 tonne	40 %	Very High	Very Low	Refillable
A_3	>10 tonnes	40 %	Average	Very High	Mixed
A_4	10 tonnes	40 %	Very Low	Average	Refillable
A_5	5 tonnes	40 %	High	Very High	Refillable
A_6	< 1 tonne	40 %	High	Very Low	Bulk VPG
A_7	< 1 tonne	40 %	High	Very Low	Refillable
A_8	< 1 tonne	40 %	Very Low	Very Low	Bulk VPG
A_9	< 1 tonne	40 %	Very Low	Very Low	Bulk VPG
A_{10}	< 1 tonne	40 %	Very Low	Very Low	Refillable
A_{11}	< 1 tonne	20 %	High	Very Low	Mixed
A_{12}	< 1 tonne	20 %	High	Very High	Mixed
A_{13}	< 1 tonne	20 %	High	Very Low	Mixed
A_{14}	< 1 tonne	50 %	High	Very Low	Mixed
A_{15}	>10 tonnes	>50 %	High	Very High	Bulk VGG
A_{16}	>10 tonnes	>50 %	High	Very High	Bulk VGG
A_{17}	< 1 tonne	20 %	Average	Very Low	Mixed
A_{18}	< 1 tonne	20 %	Average	Very Low	Mixed
A_{19}	< 1 tonne	20 %	Average	Average	Mixed
A_{20}	5 tonnes	20 %	Very High	Average	VPG and Mixed
A_{21}	5 tonnes	50 %	Very High	Average	VPG and Mixed
A_{22}	5 tonnes	50 %	Very High	Average	VPG and Mixed
A_{23}	>10 tonnes	>50 %	Very High	Very High	Bulk VGG
A_{24}	>10 tonnes	>50 %	Average	Very High	Bulk VGG
A_{25}	>10 tonnes	>50 %	Average	Very High	Bulk VGG
A_{26}	1 tonne	>50 %	Very High	Average	VPG and Mixed
A_{27}	1 tonne	20 %	Very High	Average	VPG and Mixed
A_{28}	1 tonne	20 %	Average	Average	VPG and Mixed
A_{29}	1 tonne	20 %	Very High	Average	Bulk VPG
A_{30}	1 tonne	10 %	Average	Average	Bulk VPG
A_{31}	1 tonne	20 %	Very High	Average	Bulk VPG
A_{32}	10 tonnes	>50 %	Very High	High	VPG and Mixed
A_{33}	< 1 tonne	10 %	Average	Very Low	Mixed
A_{34}	1 tonne	10 %	Average	Low	Mixed
A_{35}	1 tonne	10 %	High	Very High	Mixed
A_{36}	10 tonnes	50 %	Very High	Very High	Bulk VPG
A_{37}	10 tonnes	50 %	High	Very High	Bulk VPG
A_{38}	>10 tonnes	10 %	Very High	Very High	Bulk VGG
A_{39}	>10 tonnes	40 %	High	Very High	Bulk VGG
A_{40}	>10 tonnes	20 %	High	Very High	Bulk VGG

Appendix 2 – Final optimistic and pessimistic classification

Alternative	Optimistic	Pessimistic	Alternative	Optimistic	Pessimistic
1	CLS2	CLS2	21	CLS5	CLS5
2	CLS5	CLS5	22	CLS3	CLS3
3	CLS4	CLS4	23	CLS2	CLS2
4	CLS3	CLS3	24	CLS4	CLS4
5	CLS4	CLS4	25	CLS3	CLS3
6	CLS3	CLS3	26	CLS2	CLS2
7	CLS1	CLS1	27	CLS5	CLS5
8	CLS1	CLS1	28	CLS5	CLS5
9	CLS5	CLS5	29	CLS3	CLS3
10	CLS5	CLS5	30	CLS2	CLS2
11	CLS5	CLS5	31	CLS2	CLS2
12	CLS3	CLS3	32	CLS1	CLS1
13	CLS3	CLS3	33	CLS2	CLS2
14	CLS3	CLS3	34	CLS4	CLS4
15	CLS3	CLS3	35	CLS2	CLS2
16	CLS1	CLS1	36	CLS3	CLS3
17	CLS1	CLS1	37	CLS4	CLS4
18	CLS1	CLS1	38	CLS4	CLS4
19	CLS2	CLS2	39	CLS4	CLS4
20	CLS3	CLS3	40	CLS4	CLS4

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