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ARTICLES

RANKING OF A SET OF ACCOUNTS RECEIVABLE STRATEGIES IN A MEXICAN REGIONAL COMPANY BASED ON A MULTICRITERIA APPROACH

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ABSTRACT. Account receivable can help companies expand sales and reduce inventory; however, bad debt in account receivable is not uncommon, and it dramatically occupies company funds. Therefore, the study on the problems existing in managing the account receivable of a company is necessary. For this reason, the selection of a final accounts receivable strategy needs to consider at least two factors of importance: decision-maker preferences and fuzzy preference information in the decision criteria. In this paper, a multicriteria approach for ranking a set of accounts receivable strategies in a company is proposed, and the case of a Mexican regional company is presented. The proposed model considers all the above factors. The approach uses the ELECTRE III method to obtain a recommendation per the decision maker's preferences. The results showed that the most preferred alternative is visiting an account receivable executive at home and agreement calls. Insights gained from this applied research had practical implications for the decision-maker, including a better understanding of the problem and its value, reflected in a credit management department setup.

Keywords: Accounts receivable, multicriteria decision analysis, ELECTRE III method.

1 INTRODUCTION

Account receivable refers to the total price of the goods that the company should collect from the purchaser or the unit that accepts labor services during the normal business process, the taxes paid, and purchase the debtor side of the transport fees and other advances. Account receivable exists along with the generation of credit sales business and is a critical means for companies to expand sales, increase market share and reduce

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inventory backlog (Li, 2019). It also enhances the competitiveness of companies in the market; on the other hand, account receivable is the occupation of funds. Therefore, it has a significant impact on the turnover of the company's capital. Therefore, strengthening the management of accounts receivable is a significant problem facing the sustainable development of the enterprise. The effective management of the account receivable is to improve the internal control of the account receivable. Effective control can effectively accelerate the recovery of account receivable, reduce the bad debt losses and improve the economic benefits of companies.

The evaluation, monitoring, and control of accounts receivable are processes that ensure that payments are made timely and effective. This activity includes the ranking or the classification of the accounts according to their type and different natures, such as current accounts, overdue accounts, and accounts hard to recovery. The accounts receivable management must have strict control over this activity since the accounts must be financed from short and long-term sources; their mismanagement negatively affects its liquidity (Montibeller et al., 2008). Every time a company makes sales on credit, there is a risk that a percentage of customers do not pay their debts. Therefore, it faces money losses since it will not be possible to recover the total amount sold on credit (Mian & Santos, 2018). With the premise that the management of accounts receivable is the axis on which the company's liquidity revolves and the main component of the cash flow, its mismanagement could be the leading cause for insolvency problems (Siekelova et al., 2015) (Cash & Tsai, 2018).

Nowadays, companies offering credit search for new techniques and analysis tools, with the primary purpose of evaluating and identifying the most effective debts recovery actions and focusing their efforts on those actions that generate a higher cash flow recovery (Montibeller et al., 2008). These initiatives lead companies to complex decision situations where they are forced to reduce their operating costs, improving their client services while at the same time investing in new technologies and strategies. In general, the techniques and tools used to deal with complex situations in the accounts receivable process use criteria such as payment due days of accounts receivable, the total amount of receivable accounts, experience with the debtor, and many debtors for classification or ranking (Beck, et al., 2017).

Some researchers have addressed these types of problems through a measurement approach (Beck, et al., 2017; Wang, 2018; Li, 2019; Richard & Kabala, 2019) using descriptive statistics and multivariable regression models. These methods are used to find relationships between variables and their effectiveness in recovery strategies of debt. On the other hand, there have been used econometrics models with financial indicators such as the Cash Conversion Cycle (CCC) or the financing time of accounts receivable to analyze the impact between the historical accounts receivable strategic changes made by companies and their efficacy in the accounts receivable process (Batrancea et al., 2018; Masood et al., 2018; Moussa, 2018).

However, this type of methodology does not allow accurate modeling of the decision-maker (DM) preferences. Neither do they consider the actors, the potential actions, the company's resources, the problematic situation, and the problem's structuring. When facing the accounts receivable strategies problem, the DM must consider a finite set of available decision alternatives; thus, under this scenario, it is feasible to use a multicriteria decision analysis (MCDA) approach to address such a problem. Usually, no single criterion captures each alternative's performance (Bouyssou et al., 2006). Besides, in MCDA, it is possible to reduce the methodological bias, obtain greater accuracy than traditional management methods, and adequately model the subjectivity in the accounts receivable problem.

MCDA is an operational research field that allows dealing with decision problems; where there is a set of alternatives assessed by a group of criteria, some of these criteria may conflict with each other (Leyva Lopez,

2005). MCDA approach aims to offer procedures to the decision-maker to solve its decision problems. These procedures can be translated into prescriptions or recommendations regarding the decision-making that should be performed (Figueira et al., 2013).

At least two key factors induce a significant accounts receivable strategy: *i*) decision-maker preferences based on their know-how and practice with accounts receivable, and *ii*) fuzzy (imprecise and uncertain) preference information in the decision criteria. Concerning factor (*i*), the accounts receivable strategies can utilize the decision maker's preferences to state the strategy performance in terms of its attributes. Additionally, a decision-maker can include the details of viable strategies in their aggregation model of preferences so that the new strategy can be appropriately placed in the account recovery business environment. Concerning factor (*ii*), the criteria levels can deviate from their real values and alter the strategy performance because of the uncertainty in the model parameters for the accounts receivable strategy (such as thresholds of preference and indifference). This type of uncertainty can break a strategy in the account recovery business environment; thus, it is significant to consider these strategy variations.

This paper aims to construct a multicriteria model to evaluate a set of accounts receivable strategies in a Mexican regional company in the Northwest of Mexico. In the literature, we observed different approaches to tackle the accounts receivable strategies problem, such as the descriptive, the normative, and the decision aid, divided into two types of knowledge: i) on a priori and ii) a posteriori. Most of the research in the literature focus on a posteriori knowledge that aims to analyze the changes resulting after applying a specific approach. However, there has been little attention to a priori type of knowledge, which aims to focus on defining the way to analyze the data to drive a result. The research seeks to provide the literature with a new way of addressing restructuring accounts receivable strategies. The innovation consists of using a new approach, such as the constructive approach, an MCDA model, and an outranking method, such as the ELECTRE III method. As far as we know, this is the first reported application of the ELECTRE III method to the accounts receivable strategies problem.

The proposed multicriteria approach utilized in this study is simple. Furthermore, it can treat uncertainty well. The proposed methodology is rigorous and recommends a solution to the problem per the decision maker's preferences. Insights gained from this applied research have practical implications for decision-makers and finance managers.

Contributions account for the above two key factors, which enhance understanding for inducing accounts receivable strategies. The investigation into various key factors' modeling provides empirical evidence for decision-makers/analysts in models evaluation for accounts receivable. Moreover, the research indicates that these factors are appropriate for solving the accounts receivable strategies problem. For example, allowing decision-makers to provide various types of preference information would increase the information elicitation procedure's flexibility and reduce decision-makers cognitive burden.

Furthermore, this research shows that when comparing accounts receivable strategies based on the outranking approach of MCDA, the decision-maker also gains the expressiveness of the underlying preference model and the robustness of the preference model's recommendation. Outranking relations is an alternative model far more flexible than additivity utility models for obtaining those preferences and imposes fewer preferences requirements. Fuzzy outranking relations can be used to consider the non-compensatory impacts between criteria when consumers state their preferences.

The paper is organized as follows: Section 2 presents a literature review related to the problem studied. After that, in Section 3, the ELECTRE III method is described. Later, in Section 4, the problem statement

is developed, particularly the problem situation and problem formulation. Next, the evaluation model is presented in Section 5. After that, in Section 6, the results are analyzed. Finally, the discussion and the main contributions to knowledge are exposed in Section 7, and conclusions are presented in Section 8.

2 LITERATURE REVIEW

The accounts receivable process is a crucial factor in maintaining healthy cash flow in any company's operations. An increase in the number of accounts receivable could represent a decrease in cash flow and an increased risk that many customers will not pay their debts, which constitutes a loss. This implies that some companies must operate with a high accounts receivable rate and be very efficient in recovering them. The problem of restructuring accounts receivable strategies consists of finding the correct selection of strategies in the accounts receivable administration that increases debt recovery efficiency. In turn, they are better adapted to the nature of the company.

Most of the methods used to solve the problem of restructuring accounts receivable strategies found in the literature used a posteriori knowledge through a deductive process. This research shows recent works published in the 2006-2019 period. These works present a variety of approaches, methodologies, and methods such as engagement-based approach, descriptive statistics methods, descriptive approach, descriptive methods, exploratory approach, multiple regression method, functional approach, regression methods, object-oriented methodology, optimizations method, measurement approach, econometric methodologies, and fuzzy multiple criteria decision-making and decision support approach.

We classified the works into three main general approaches, the descriptive method, the normative approach, and the decision support approach. Within the descriptive process, Hasan & Saha (2014) analyzed customers' credit behavior and examined the receivables' investment and the credit facility granted to them. An engagement-based approach has been undertaken rather than the traditional mere statistical empirical approach. In Kaur et al. (2017), the debtor management system and credit policy of an Indian company are studied and analyzed. Techniques such as descriptive statistics are used to analyze the data. (Beck, et al., 2017) proposed to use a descriptive approach, studying debt collection agencies (DCAs) in two ways: first presenting an estimation of the collection rates and investigating potential determinants of the collection success and accounts receivable strategies. s. Fedaseyeu and Hunt (2018) analyzed a collection of accounts receivable strategies, a collection policy from a group of companies with a collection system, and some collecting companies. In their study, they used a descriptive methodology to create the models that companies follow for collection. Leontieva et al. (2019) propose a credit rating formation pattern using a descriptive approach, which makes it possible to eliminate the problem of unmotivated issuing credits to contractual partners of long-term cooperation, assuming that they have past-due accounts receivable. In Li (2019), an analysis of accounts receivable's internal control strategies in Chinese SMEs was implemented using a descriptive approach. Richard & Kabala (2019) used an exploratory approach and was informed by the asymmetric information theory. A content analysis was used for the data analysis focusing on establishing how micro, small, and medium enterprises (MSMEs) operating in Tanzania manage the account receivable. Finally, Zhu, Dai & Wu (2019) used a descriptive approach. They employed a panel data model to discuss the accounts receivable determinants and analyze the impact of financial leasing and accounts receivable in China's equipment manufacturing industry.

On the other hand, considering a normative approach, Ikechukwu & Nwakaego (2015) examine accounts receivable management on the profitability of building materials, chemical, and paint companies in Nigeria using a multiple regression method. Huijun & Jing (2016) presented an investigation of the bank's expecta-

tion profit and accounts receivable, using a functional approach with a mathematical model, which incorporates a financing ratio and relevant influence factors to provide accounts receivable finance to the domestic small and medium enterprises. Yao & Deng (2017) provided important information about CEO compensation incentives, a new explanation about the formation of accounts receivable management policy, and the market value implication of accounts receivable. They used sorting, various regression methods and adjusted the Faulkender & Wang (2006) model to test two hypotheses. The research Karma & Susanti (2017) aimed to build information systems to handle account payables and receivables related to the purchase and sale of tour packages on credit; the methodology used the object-oriented by using MySQL. Wang (2018) analyzed the accounts receivable situation in Haier Group and redesigned the accounts receivable internal control system using an optimization method to find the complete set of the Group Institutions' optimal design. Masood et al. (2018) used a data collection variable measurement and an econometric methodology to develop an empirical model and an effect estimator for analyzing the impact of working capital management on conventional banks' cash holding decisions in Pakistan from 2006 to 2016.

The problem of restructuring accounts receivable strategies plays a significant role in decision-making in managing accounts receivable, which in most cases contains multiple criteria. However, although it seems natural to evaluate account receivable strategies under a multiple criteria approach, we found only three works incorporating such methods to support decision-making. In this regard, Hung, Li & Chianga (2006) presented a fuzzy multiple criteria decision-making (FMCDM) approach to the evaluation and ranking of account receivable (A/R) collection instruments in microelectronics and optoelectronics industries in Taiwan. Per the results, the difference in the ranking preference between the two industries is observed. Afterward, Hung, Li & Chianga (2006) extended their previous work considering four collection alternatives and proposing a study that chooses to make critical decisions in selecting A/R collection instruments. Finally, Wu, Olson & Luo (2014) described and demonstrated a model to support accounts receivable risk management for a large bank, using a decision support approach through a rating system and a selected logistic regression model to analyze the risk of accounts receivable.

In Table 1, we present the classifications we made for the literature review and a summary of the contributions of each of the works presented. We classify the results per their decision-making approach (Descriptive, Normative, and Decision Support approaches), and we also describe the methodology used in the research.

Table 1 – Summary and classifications of the literature review.

Focus	Methodology	Author (Year)	Key findings
Descriptive method	Semi-structured interview	Hasan, S., & Saha, A. K. (2014).	This research presents a case study in a company in Bangladesh that proposes an approach to define appropriate credit policy for account receivable management and to analyze the empirical credit distribution process and the commercialization channels carried out by the company. Such an approach contributed to the definition of best practices for managing accounts receivable in Bangladeshi companies.
	Descriptive statistics	Kaur, B., Jindal, L., & Jindal, S. (2017).	This research aims to build a system for debtor management based on credit policies, an existing account receivable management system, and interviews made to the credit and collection area using statistical analysis. The main contribution found in this study was the established system that gives companies the freedom to monitor the results of conventional credit policies.
	Descriptive statistics	Beck, T., Grunert, J., Neus, W., & Walter, A. (2017).	This research looks for potential determinants of the collection success, using descriptive statistics, concluding a negative correlation between the age of the account and the collection rate; the collection rate is lower if the debtor has gone through a collection process. Prior experience with the debtor seems to help achieve very high collection rates, among other conclusions, using regression models to a series of accounts receivable.
	Descriptive statistics	Fedaseyeu, V., & Hunt, R. M. (2018).	In this paper, the authors analyze the difference between the debt collection process within enterprises and third-party firms' collectors, providing insights into which policy interventions may improve the functioning of the debt collection market. This paper concludes that the existence of third-party debt collectors works if the size of the delinquent credit mark is large enough to warrant it. Still, at the same time, it hurts the consumer who follows conventional collection practices.
	Descriptive statistics	Leontieva, J., Klychova, G., Zakirova, A., Zaugarova, E., Maletskaya, I., & Khamidullin, Z. (2019).	This paper defines a collector control based on internal and external sources of information to prevent or minimize debtors' risk. Such a collector control allowed a decrease of credit default and the increment in the efficiency of ongoing transactions; thus, it helped maintain the enterprise's financial stability.
	Balanced scorecard	Li, A. (2019).	The author discusses the internal control of account receivables in a sample of small and medium-sized enterprises in China, suggesting that using a balanced scorecard to analyze the credit deficiencies can be used as an effective strategy to improve business benefits.
	Asymmetric information theory, descriptive statistics	Richard, E., & Kabala, B. (2019).	This research focuses on describing management debtors' process on small and medium enterprises in Tanzania using the asymmetric information theory and data analysis to determine a formal credit risk management process. The authors concluded that there is a problem of asymmetric information in the companies analyzed. However, they all use similar systems for collection to deal with asymmetric information.
	Interviews, descriptive statistics	Zhu, C., Dai, Y., & Wu, Y. (2019).	This paper analyzes the impact between financial leasing and accounts receivable in a company from China using a regression model to determine significant variables. The paper's findings are that the finance leasing variable has a significant impact on accounts receivable.

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Focus	Methodology	Author (Year)	Key findings
Normative approach	Multiple regression analysis	Ikechukwu, O. I., & Nwakaego, D. A. (2015).	This research uses empirical analysis to look for a relationship between receivable management and corporate profitability in some companies in Nigeria using multiple regression on some variables such as the return on asset ratio, accounts receivable ratio, debt ratio, and sales growth rate. Results showed that accounts receivable had positive and significant effects on the profitability ratio.
	Supply chain	Huijun, H., & Jing, Z. (2016).	This study analyzes how a bank's resource accounts receivable factoring ratio is influenced by credit and exchange risks based on a multinational supply chain. Results show that the factoring financing ratio exchange increases when the rate prediction value and the compensation rate decrease when the exchange rate fluctuation range, financing time, factoring cost rate, and the bank capital costs rate are high.
	Regression method	Yao, H., & Deng, Y. (2017).	This research studies the influence of managerial compensation incentives in the receivable management policy. A significant negative relation between managerial risk-taking incentives (VEGA) and accounts receivable was found, concluding that more outstanding VEGA encourages more excellent accounts receivable reduction.
	Object-oriented approach	Karma, I. G., & Susanti, J. (2018).	This paper presents an information system for a travel company that manages accounts receivable and account payable processes. It details the flow of the proposed information system to efficiently handle accounts receivable and payable, concluding that integration with other systems such as reservation and accounting systems could facilitate the management of all areas.
	Econometric methodology	Masood, A., Gulzar, S., & Quddoos, M. U. (2018).	This paper study the impact of working capital management by analyzing a collection variable measurement and using an econometric methodology to estimate an empirical model. Its findings show that working capital management is critical because it directly affects the business's liquidity.
Decision support approach	MCDM, FAHP	Hung, C.-Y., Li, Y., & Chianga, Y. H. (2006).	This paper presents a fuzzy multicriteria decision-making approach to evaluate account receivable collection instruments to obtain a ranking of account receivable tools using a fuzzy AHP method to determine the weights of decision criteria and establish a group of DMs integrated by experts and the finance manager. It concluded that there is a certain similarity between the analyzed companies. Furthermore, the ranking of preferences shows that compliance with firm policy, reduction in transaction risk, and reduction in transaction cost are the best-ranked criteria.
	Data mining, machine learning	Wu, D. D., Olson, D. L., & Luo, C. (2014).	This paper presents a decision support model for the accounts receivable risk management problem. This model assesses account creditworthiness by using a logistic regression model. Results show that the proposed logistic regression model presents better accuracy than other similar risk management scores, such as the Beacon score.
	Markov process and discriminant analysis	Zopounidis (1999)	Although this paper is not focused on accounts receivable, it is essential to state the importance and contributions of MCDA as techniques for financial decisions in businesses. Among several financial problems exposed in this paper, the author suggests that Markov process and Discriminant analysis can be used as techniques for managing accounts receivable.

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Focus	Methodology	Author (Year)	Key findings
	DSS based on reasoning maps	Montibeller et. al. (2007)	Presents some reflections on an empirical research intervention using a reasoning map about the use of DSS to help decision-making in accounts receivable management in small enterprises in developing countries, emphasizing Brazilians' enterprises. This paper does not provide a specific model for this kind of problem; instead, it aims to give a better understanding of the problem by using a DSS highlighting the importance of focusing on structuring the problem and operating models based on linguistic terms as these seems to be a weak practice in developing countries.
	Fuzzy comprehensive and AHP	Luo & Zhiya (2013)	This paper proposes a client credit evaluation index system for logistic enterprises. For the construction of the index, the authors propose to model the problem using the comprehensive fuzzy method combined with AHP on ten indexes that are relevant to this kind of business. The model allows to evaluate any customer and get a score that reflects its quality for the company. Results presented on a practical case study show the applicability of the model. However, although the model seems prominent, it lacks objectivity; thus, it requires more research to be less subjective.
	DSS and value functions	Ensslin Neto & de Lima (2000)	This paper presents a DSS based on value functions, named RiskInvest, adapted to the financial business process of a Brazilian factoring company to tackle their accounts receivable management to evaluate their risk for decision-making support. The paper describes the whole process that a group of consultants followed, from understanding the problem to the model and the DSS construction. It also details the modules of the DSS and how it works. This paper does not present any evaluation for the DSS; thus, further analysis on its performance or comparison with other models can be made. However, the main contribution is that it can be used to understand how the accounts receivable process is carried on small or medium companies and how a DSS can be constructed and implemented to aim decision-making.

3 THE ELECTRE III METHOD

ELECTRE methods are outranking-based methods (Roy, 1996). They start by building one or several comprehensive outranking relations, followed by exploiting this (these) relation(s). The ELECTRE III method constructs a single outranking relation. The exploitation phase of this outranking relation consists of rank-ordering the alternatives in decreasing order of preferences. In ELECTRE III, the result of the outranking test concerning a pair of alternatives $(a,b)\in A\times A$, is positive when the value of the credibility index is not smaller than a fixed cutting level. This credibility index synthesizes, in a comprehensive way, the strength of the coalition of criteria being in favor of the assertion "a is at least as good as b, aSb" with the opposition of criteria being against this assertion.

3.1 The outranking relation

Let $A=\{a_1,a_2,...,a_m\}$ be a set of alternatives assessed by a group of criteria $G=\{g_1,g_2,...,g_n\}$. The outranking relation is a binary relation between the elements of A. This outranking relation can be represented by S. Given two alternatives $a,b\in A$, aSb says that "a outranks b" which means that "a is at least as good as b". Considering the preferences of a DM aSb is true if there are enough arguments to proclaim that "a is at least as good as b "and there are no strong motives to refute such an assertion. There are different types of outranking relations:

- Single outranking (aSb): a is preferred or indifferent to b.
- Double outranking (aSb and bSa): a is indifferent to b, it is denoted by aIb.
- Non-outranking ($a\neg Sb$): Both alternatives are incomparable "a no outranks b" represented by $a\neg Sb$

As soon as two alternatives $a,b\in A$ are compared, one and only one of the following relations is generated:

- aSb and $\neg(\ bSa$: a outranks b and b does not outrank a. (Preference).
- $\neg(\ aSb$ and bSa: a does not outrank b and b outranks a. (Preference).
- aSb and bSa: a outranks b and b outranks a. (Indifference).
- $\neg(\ aSb$ and $\neg(\ bSa$: a does not outrank b and b does not outrank a. (Incomparability).

3.2 Thresholds

ELECTRE III introduces the threshold notion, which can be understood as a value that a DM states when an alternative a is indifferent or preferred to an alternative b, where $a,b\in A$. Thresholds are utilized in ELECTRE III to construct the outranking relation S. There are three types of thresholds in ELECTRE III: indifference q, preference p, and veto v.

The indifference threshold gives rise to the following relationships:

$aPb\leftrightarrow g(a)>g(b)+q$ (a is preferred to b).

$aIb\leftrightarrow |g(a)-g(b)|\leq q$ (a is indifferent to b).

When the DM doubts if an alternative a is indifferent or preferred to b, it says that there is a weak preference (Q relation):

aQb: a is weakly preferred to b if there is doubt that aIb and aPb (being sure that $b\neg Pa$).

bQa: b is weakly preferred to a if there is doubt that aIb and bPa (being sure that $a\neg Pb$).

The weak preference is a binary relation modeled through the preference threshold p as follow:

$aPb \leftrightarrow g(a) > g(a) - g(b) > p$ (a is strictly preferred to b).

$aQb \leftrightarrow q < g(a) - g(b) \leq p$ (a is weakly preferred to b).

$aIb \leftrightarrow g(a) - g(b) \leq$ (a is indifferent to b).

When two alternatives $a,b \in A$ are incomparable each other, it says an incomparability relation, denoted by R:

aRb: a is incomparable to b if there is doubt that aPb and bPa.

The veto threshold v is utilized to reject the asseveration " a is at least as good as b", where $a,b \in A$; even if in a global sense, a has the best performance in most of the criteria that b. This is applied if, for any criterion $j \in G$, it occurs $g_j(b) > g_j(a) + v_j$. Typically, the veto threshold is used only in essential criteria.

3.3 Weights

The weights used in ELECTRE III are considered coefficients of relative importance. These weights can be seen as votes for each criterion "candidates" (Vincke 1992). For each criterion, weight w is defined. Weights are used to form the Concordance index.

3.4 Concordance and Discordance indexes

To establish if aSb is true, ELECTRE III uses the majority and minority principles of democracy. To do this, it builds the concordance and discordance indexes, respectively. The concordance index groups all criteria in favor of the aSb statement. On the other hand, the discordance index considers at least one criterion strongly disagrees with aSb. If there is a disagreement in that sense, the assertion aSb is vetoed, even if most of the criteria are in favor of aSb; hence, the importance of the veto threshold.

The set of criteria that agrees with aSb is known as the concordance coalition, denoted by $C(a,b)$. The collection of criteria in disagreement with aSb is known as the discordance coalition, which is indicated by $D(a,b)$.

Through the principles of concordance and discordance, it is possible to know the strength of aSb by using the concordance index and discordance index. Considering w_j as the weight or relative importance of the criterion j, where $j = 1,\ldots,n$, the concordance index is defined as follows:

$$C(a,b) = \frac{1}{W}\sum_{j=1}^{n} w_j c_j(a,b) \tag{1}$$

where:

$$W = \sum_{j=1}^{n} w_j$$

and,

$$c_j(a,b) = \begin{cases} 1, if\, g_j(a) + q_j \geq g_j(b) \\ 0, if\, g_j(a) + p_j \leq g_j(b) \\ \frac{p_j + g_j(a) - g_j(b)}{p_j - q_j},\ otherwise \end{cases} ; j = 1,\ldots,n$$

On the other hand, the discordance index, by using the veto threshold, allows the possibility to reject *aSb*, if for every criterion j, $g_j(b) > g_j(b) + v$. This index is defined as follows:

$$d_j(a,b) = \begin{cases} 1, if\, g_j(a) + v_j \leq g_j(b) \\ 0, if\, g_j(a) + p_j \geq g_j(b) \\ \frac{g_j(b) - g_j(a) - p_j}{v_j - p_j}, otherwise \end{cases} ; j = 1, \ldots, n \quad (2)$$

Once calculated the concordance and discordance indexes, it is necessary to generate an index or degree of credibility to assess the statement's strength, "a is at least as good as b". For each pair $a, b \in A$, the credibility index is constructed using the concordance and discordance indexes as follows:

$$\sigma(a,b) = \left\{ \begin{matrix} C(a,b), if\, d_j(a,b) \leq C(a,b)\, \forall j \\ C(a,b) \bullet \prod_{j \in J(a,b)} \frac{1 - d_j(a,b)}{1 - C(a,b)} \end{matrix} \right\} J(a,b)\ is\ the\ set\ of\ criteria\ such\ that\ d_j(a,b) > C(a,b) \quad (3)$$

This formula assumes that if the concordance's strength exceeds that of the discordance, then the concordance value should not be modified. Otherwise, we are forced to question the assertion that *aSb* and change $C(a,b)$ per the above equation. If the discordance is 1 for any $C(a,b)$, $(a,b) \in A \times A$ and any criterion j, then we have no confidence that *aSb*; therefore, $\sigma(a,b) = 0$. Therefore, we have constructed a valued outranking relation relation S_A^{σ} on $A \times A$; this means that we associate with each ordered pair $(a,b) \in A \times A$ a real number $\sigma(a,b)\ (0 \leq \sigma(a,b) \leq 1)$ that reflects the degree of strength of the arguments favoring the crisp outranking *aSb*.

This concludes the construction of the outranking model. The next step in the outranking approach is to exploit the model and produce a ranking of alternatives from the valued outranking relation S_A^{σ}.

The final partial preorder of alternatives produced by the ELECTRE III method is obtained as the "intersection" of two complete preorders resulting from the so-called descending and ascending distillations (Roy, 1996). In the descending distillation, one orders the alternatives from the best to the worst. In contrast, in the ascending distillation, one ranks the alternatives oppositely, starting from the worst and finishing with the best. In the distillation procedure of ELECTRE III, the fuzzy outranking relation S_A^{σ} is converted into a crisp outranking relation using a λ-cutting level.

In the distillation procedure of ELECTRE III, we admit a set of *cut-off* levels $\lambda_j \in [0,1]$.

Given a *cut-off* level denoted by λ_j, both distillations concern the following crisp outranking relation:

$$aS^{\lambda_j}b \Leftrightarrow \begin{cases} \sigma(a,b) \geq \lambda_j \\ \sigma(a,b) > \sigma(b,a) + s(\sigma(a,b)) \end{cases}$$

Where $s(\lambda_j) = \alpha\lambda_j + \beta$ and, following (Roy, 1978), $\alpha = -0.15$ and $\beta = 0.30$.

For each alternative a, its λ_j-qualification is obtained as follows:

$$q_A^{\lambda_j}(a) = p_A^{\lambda_j}(a) - f_A^{\lambda_j}(a)$$

where: $p_A^{\lambda_j}(a) = \left| \{ b \in A : aS^{\lambda_j}b \} \right|$ is the λ_j- power of a; it is the number of alternatives outranked by a,

$f_A^{\lambda_j}(a) = \left|\{b \in A : bS^{\lambda_j}a\}\right|$ is the λ_j- weakness of a; it is the number of alternatives outranking a. The descending and ascending distillation algorithms are described in detail by Figueira et al. (2010) and Roy (1996).

In each distillation, the alternatives are ordered in classes, and each class contains at least one alternative. Thus, the final preorder is obtained as the intersection of the two distillations. Given $a, b \in A$,

- a is preferred to b (aPb) if a belongs to a class not worse than that of b in both distillations, and a better class for at least one of the two distillations,
- a is indifferent to b (aIb) if a and b belong to the same class in both distillations,
- a and b are incomparable (aRb), if a belongs to a class better than b in one distillation and worse in the other one.

4 PROBLEM STATEMENT

The research was carried out in a company dedicated to furniture sale, located in three states of México (Sinaloa, Sonora, and Nayarit), which searches for the increment of its cash flow. For this reason, the executive board has requested the credit area to increase the recovery of the debt in the accounts receivable processes, decreasing the overdue accounts, and accounts hard to recovery. Therefore, the credit manager proposes improving the accounts receivable strategies considering the type of account receivable per the payment due days, as described in Table 2. Due to his broad experience and knowledge in the credit and collection process, the credit manager will be referred to as the DM responsible for reflecting his preferences to the multicriteria model.

Table 2 – Types of accounts receivable.

Types of accounts Receivable	The payment due days
a	From 0 to 30 days of debt
b	From 31 to 60 days of debt
c	From 61 to 90 days of debt
d	From 91 to 365 days of debt
e	From 366 to 730 days of debt

Source: Own elaboration.

Type a is the set of accounts with a delay in payments from 0 to 30 days in a row. Type b is the set of accounts with a delay of 31 to 60 days and increases some days in the types c and d. Finally, type e is a set of accounts with a debt of 366 to 730 days without payment. Nowadays, the current accounts receivable strategies that are carried out consist of issuing a payment receipt per client in any account. However, for accounts receivable type *a,* no further actions are carried out. For types b and c, a request letter is issued for extra payment upon receipt of payment. For type d, an accounts receivable executive visit to the client's address is scheduled, and for type *e,* the debtor

Table 3 – Existing accounts receivable strategies.

Notation	Accounts receivable strategies
S_a	Receipt of payment
S_b	Receipt of payment and disusing a payment letter
S_c	Receipt of payment and disusing a payment letter
S_d	Visit of an account receivable executive at home
S_e	Credit bureau and address the legal department

Source: Own elaboration.

account is assigned to the credit bureau. The client is addressed to the legal department. These account receivable strategies are shown in Table 3.

The credit manager considers the need to incorporate a call center to restructure the accounts receivable strategies, meet the executive board's objectives, and propose to annex more robust strategies to pressure debtors to regularize their accounts, as shown in Table 4.

Table 4 – New set of account receivable strategies.

Notation	Accounts receivable strategies
S_a	Receipt of payment and reminder calls
S_b	Receipt of payment, issuing a payment letter, and remainder calls
S_c	Receipt of payment, issuing a payment letter, reminder call and call to the customer's guarantee
S_d	Visit of an account receivable executive at home and agreement calls
S_e	Credit bureau and address the legal department

Source: Own elaboration.

The new proposal of the credit manager to restructure the accounts receivable strategies consists of the following: For the first three types ($S_a, S_b \wedge S_c$) reminders are sent when the due date is close, to avoid possible the lengthening of the debt. For type S_c, calls are added to the customer's guarantee to apply pressure and investigate the reason for the non-payment. For the last two classes S_d and S_e, additional calls are made to reach new payment agreements. Usually, the credit manager does not have a clear idea of starting the project and asking for advice from an analyst who assists him in the decision process. In this way, the problem's situation has been analyzed according to the model of the decision support process (Bouyssou et al., 2006).

Due to the lack of liquidity, the company does not have the necessary budget to carry out a new recovery strategy throughout the accounts receivable universe. Therefore, the credit manager has been obliged to carry out the project by stages, and the next question posed, *which types of accounts receivable are the preferred ones to implement the new strategies?* Therefore, a

formulation of the ranking problem is adopted of the accounts receivable, considering various factors incorporating the following triplet (Bouyssou et al., 2006):

$$\Gamma = \langle A, V, \Pi \rangle \tag{4}$$

Where A is the set of potential actions, in this case, the different strategies related to each type of account receivable, *i. e.*, $A = \{S_a, S_b, S_c, S_d, S_e\}$; the collection V is the point of view for the evaluation. They come from the accounts receivable's nature, the size, the cash flow, and the receivable amounts of each overdue accounts. Π is the formal statement of the problem; in this case, it is the ranking of the accounts receivable strategies with the possibility of ties, in decreasing order of preference; and Γ is the combination of the three previous elements, which make up the formulation of the problem.

5 EVALUATION MODEL

Based on the formulation of the problem described in equation (4), the evaluation model step seeks to generate a model through a decision analysis method. This model can be represented as a tuple of five elements (Vincke, 1992; Bouyssou et al., 2006) as shown in equation (5).

$$M = \langle A, \{D, \varepsilon\}, H, U, R \rangle \tag{5}$$

The set of alternatives to which the model will apply is A; D is the set of dimensions, or attributes, where the elements of the set A are observed, described, and measured. Formally, D is a set of functions so that each element of A is assigned to a co-domain that we denote as x_i; ε is the set of x_i associated with each component of the set D. Intuitively we can consider the functions in D as measures using x_i as "scales"; H is the set of criteria where each element of A is evaluated taking into account the DM preferences; U is a set of uncertainty structures that apply to D and/or H; and R is a set of operators such that the information available in A, through D and H, is synthesized for a more concise evaluation. The analysis process is implemented in two stages: *i*) the parts of the model are structured and declared related to the problem and the perception of the DM following the described method (Bouyssou et al., 2006; Tsoukiàs & Ralijaona, 2015); *ii*) the application of the evaluation model to get a recommendation, looking for the answer to the research question "*which types of accounts receivable are the preferred one to implement the new strategies?*" The following sections describe each of the two stages and the parts of the model.

6 RESULTS

6.1 Problem structuration

This first stage's critical part to comply with coherence's primary conditions the model described in Vincke (1992) and Bouyssou et al. (2006). From a discussion between the DM and the analyst, the different parts of the evaluation model described were developed in the following sections.

Alternatives *(A)*. They establish the universe of discussion, including all the relations and functions used to describe the DM problem. The alternatives were defined as the five types of accounts receivable strategies. It is considered that the set of alternatives $A = \{S_a, S_b, S_c, S_d, S_e\}$; is stable

over time, which means that new alternatives will not be created or deleted. It is also considered maintaining specific formal properties such as: being a discrete subset of *n-dimensional* space, being a list of objects or an enumeration of options and having a combinatorial structure.

Dimension *(D)* and measurement scales (ε). Formally, the dimensions are a set of functions in which each element of A is assigned to a co-domain denoted by x_i. The scales are the set x_i associated with each measurement. Each x_i can be considered a set of "levels" to which a structure is possibly associated as a "ranking." The dimension results from the analysis of the four points of view introduced in the problem formulation. The sizes and scales resulting from the analysis of the problem formulation for this study are:

1. The "nature of accounts receivable" is divided into two attributes, the due payment days of each type of account receivable (days) and the percentage of debt recovery (%). These attributes are subjectively related to risk since a higher number of days without payment leads to the more incredible difficulty to recovery accounts, in the same way for a type of account receivable with a historically lower percentage of debt recovery.

2. The "accounts receivable size" is associated with the attribute of the number of debtors (#).

3. The "debt amount" represents the total amount of credit held per type of accounts receivable; this is related to the attribute of the receivable amount, which constitutes the portion of the lacking debt and is measured in Mexican pesos ($).

4. "Cash flow" is defined as the variation of the inflow and outflow of money in a period (Gitman & Zutter, 2012; Jiménez Sánchez & Rojas Restrepo, 2013) and its information measures the financial health of a company (Moreno-Meza, 2004). It is related to the Cash Conversion Cycle (CCC) attribute, which refers to the time it takes accounts receivable to become active and is measured in a certain number of days (Guajardo & Andrade, 2008).

The first, third, and fourth attributes were extracted from the company's customer database. The second and fifth attributes were discerned through the credit manager. This information was consented with the IT manager and the credit manager to arrive at a mute agreement of the attributes that should be determined to use in the method.

Criteria (H). A set of criteria should consider compliance with certain axioms as operational, exhaustive, monotonic, and non-redundant (Bouyssou, et al. 2006) (Tsoukiàs and Ralijaona 2015). The structure resulting from the analysis allows the DM to have a clear and organized idea of the problem structuring; thus, it is possible to broaden the context of the decision allowing to consider new unpredictable ways of actions to be considered. Considering the previously defined attributes in the formulation of the model, the following criteria were determined.

1. *Number of debtors (f_{nd})*. It can be modeled as a trapezoidal binary function opened to the left side, as shown in Figure 1. The DM expresses a strong preference for attention up to 20,000 debtors and a weak preference of 20,000 to 75,000 debtors; after 75,000 debtors, it is not of interest. The behavior of the function can be modeled using Equation 6.

$$f_{nd}(x) = \begin{cases} 1, if x \leq 20,000 \\ \frac{75,000-x}{75,000-20,000}, if 20,000 \leq x \leq 75,000 \\ 0, if x > 75,000 \end{cases} \quad (6)$$

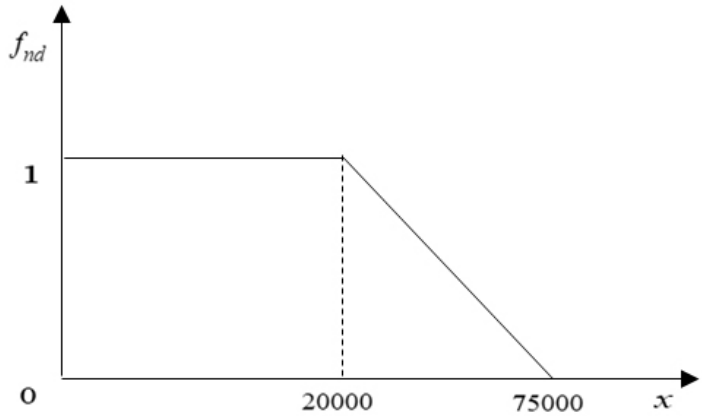


Figure 1 – The trapezoidal binary function opened to the left to model the number of debtors.

Source: Own elaboration.

Then we can say that an alternative S_i is preferable to an alternative S_j or "at least as good as" if $f_{nd}(S_i) \geq f_{nd}(S_j)$, where $f_{nd}(S_i)$ is the preference degree of the number of debtors within a type of accounts receivable (i).

2. *Payment due days (f_{pdd})*. It can be modeled as a fuzzy trapezoidal function, as shown in Figure 2.

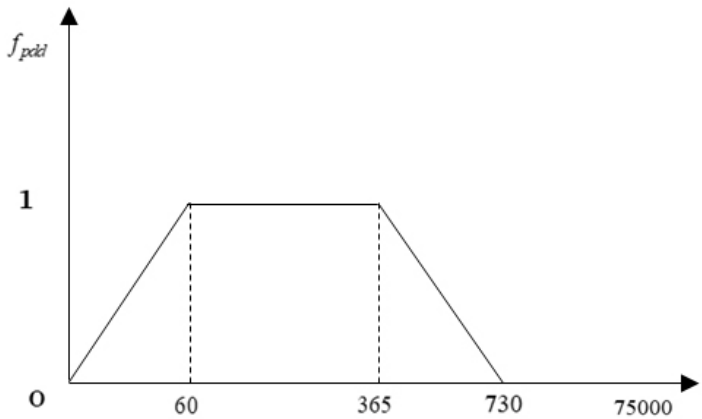


Figure 2 – Trapezoidal fuzzy function to model the due payment days.

Source: Own elaboration.

Where the DM expresses a weak preference for the type of accounts receivable that are less old than 60 days while showing a strong preference for overdue accounts with 60 to 365 payment due days, a weak preference for accounts hard to recovery that are between 365 and 730 payment due days, any account higher old than 730 days is no longer attractive to the DM. The behavior of this function can be modeled using Equation 7.

$$f_{pdd}(x) = \begin{cases} \frac{x}{60}, if 0 \leq x \leq 60 \\ 1, if 60 \leq x \leq 365 \\ \frac{730-x}{365}, if 365 \leq x \leq 730 \\ 0, if x > 730 \end{cases} \tag{7}$$

Therefore it can be defined that an alternative S_i is preferable to an alternative S_j or "at least as good as" if $f_{pdd}(S_i) \geq f_{pdd}(S_j)$, where $f_{pdd}(S_i)$ is the preference degree of the *payment due days* within of a type of accounts receivable (i). The DM is interested in releasing debts within a year without payment because, from his own experience, the client is unlikely to seek to liquidate his account if it is more than a year old.

3. *Receivable amount (f_{rm})*. It can be modeled as a fuzzy trapezoidal function open to the right side, as shown in Figure 3, where the DM expresses a weak preference for debt amounts from \$0 to \$25,000,000 and a strong preference for equal or higher amounts to \$ 25,000,000. The behavior of the function can be modeled using Equation 8.

$$f_{rm}(x) = \begin{cases} \frac{x}{25,000,000}, if 0 \leq x \leq 25,000,000 \\ 1, if x \geq 25,000,000 \end{cases} \tag{8}$$

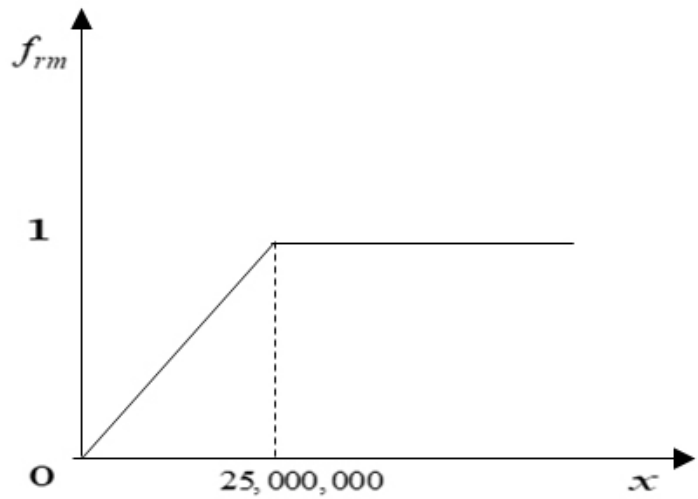


Figure 3 – The fuzzy trapezoidal function is open to the right side to model the receivable amount.

Source: Own elaboration.

Considering the above, an alternative S_i is preferable to an alternative S_j or "at least as good as" if $f_{rm}(S_i) \geq f_{rm}(S_j)$, where $f_{rm}(S_i)$ is the preference degree of the *receivable amount* within a type of accounts receivable (i). This criterion is to maximize, given that the DM should recover the most significant amount of possible debt.

4. *Percentage of debt recovery (f_{prd})*. It can be modeled as a fuzzy trapezoidal function open to the left, as shown in Figure 4.

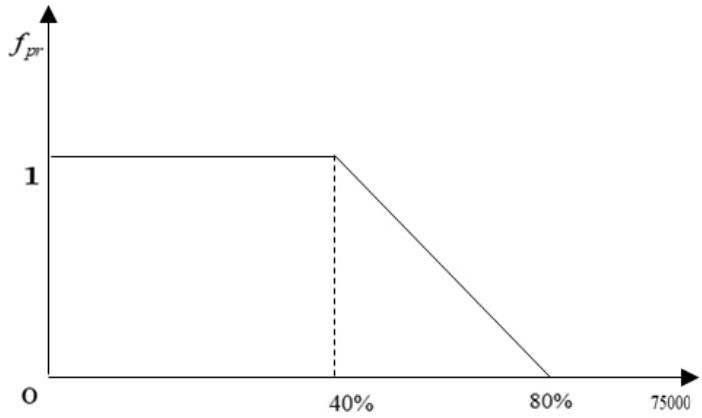


Figure 4 – The fuzzy trapezoidal function is open to the left to model the percentage of debt recovery.

Source: Own elaboration

Where the DM expresses a strong preference for the percentages of revenue equal or below to 40% and a weak preference for the rates from 40% to 80%, the accounts receivables after 80% are not preferred, the behavior of the function can be modeled using Equation 9.

$$f_{prd}(x) = \begin{cases} 1, if x \leq 40 \\ \frac{80-x}{40}, if 40 \leq x \leq 80 \\ 0, if x > 80 \end{cases} \tag{9}$$

In this criterion, an alternative S_i is preferable to an alternative S_j or "at least as good as" if $f_{prd}(S_i) \geq f_{prd}(S_j)$, where $f_{prd}(S_i)$ is the preference degree of the *percentage of debt recovery* within a type of accounts receivable (i). Here, a criterion to be maximized is sought since a small percentage means a greater area of opportunity or a deficiency in the current accounts receivables strategies.

5. *Cash conversion cycle (f_{ccc})*. It can be modeled as an open trapezoidal fuzzy function to the right side offset according to the origin, as shown in Figure 5, where the DM expresses indifference for a *CCC* ranging from 0 to 30 days. A CCC's weak preference is from 30 to 40 days, and a strong preference for a *CCC* is equal to or greater than 40 days. The behavior of the function can be modeled using Equation 10.

$$f_{ccc}(x) = \begin{cases} 0, if 0 \leq x < 30 \\ \frac{x-30}{10}, if 30 \leq x \leq 40 \\ 1, if x > 40 \end{cases} \quad (10)$$

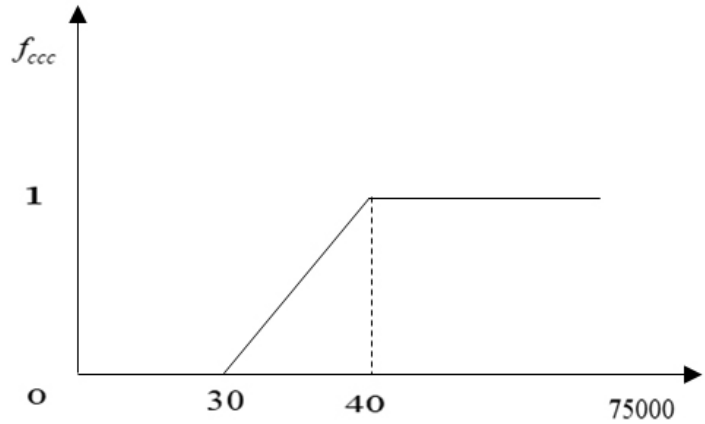


Figure 5 – Open fuzzy trapezoidal function to the right side according to the origin to model the cash conversion cycle.

Source: Own elaboration.

In this criterion, an alternative S_i is preferable to an alternative S_j or "at least as good as" if $f_{ccc}(S_i) \geq f_{ccc}(S_j)$, where $f_{ccc}(S_i)$ is the preference degree of the *cash conversion cycle* within a type of accounts receivable (i). This study considers a *cash conversion cycle* of each kind of account receivable in days. In other words, the higher the number of days, the period of need for working capital increases, and the liquidity of the company, being of interest in these areas of opportunity that reflect deficiencies in the current accounts receivables strategies.

Aggregation procedure. This is the set of operators that allow obtaining a relation or normal function in *A,* which is used to infer a final recommendation. The purpose of the aggregation process is to determine a ranking with the possibility of ties, looking for the most relevant alternatives found in the upper part and in the opposite way in the lower part. This ranking will help decide the call center's size in its initial and subsequent stages; the possibility of managing ties will help identify which types of accounts receivable have the same level of importance.

Different MCDA methods have been developed and applied to resolve decision-making problems, where the ELECTRE family stands out (Govindan & Jepsen, 2016). It is especially true for the ELECTRE III method. Several factors influenced the specific selection of the ELECTRE III method for accounts receivable strategies in a Mexican regional company settled in the Northwest of Mexico. First, a set of discrete alternatives and a set of financial dimensions can be easily converted into a set of criteria. Additionally, the problem type addressed in this study can be modeled as a multicriteria ranking problem. Based on the literature, the ELECTRE family of

methods is considered appropriate for addressing a problem type such as the one addressed in this study (see Roy, 1996). This is especially true for the ELECTRE III method. Second, ELECTRE was initially developed by Roy to incorporate the fuzzy (imprecise and uncertain) nature of decision-making by using thresholds of indifference and preference. This feature is appropriate for solving this problem. Third, an additional part of ELECTRE, which distinguishes it from many multicriteria solution methods, is fundamentally non-compensatory (Ishizaka & Nemery, 2013).. This means that good scores on other criteria cannot compensate for a terrible score on a criterion. Fourth, another feature is that ELECTRE models allow incomparability. Incomparability, which should not be confused with indifference, occurs between some alternatives *a* and *b* when there is no clear evidence in favor of some type of preference or indifference. Finally, the choice of ELECTRE III was also influenced by successful applications of the approach (see Govindan & Jepsen, 2016) for a list of successful applications of ELECTRE). This paper uses the ELECTRE III method to aggregate the decision maker's preferences and derive a partial order of accounts receivables strategies in decreasing order of preferences.

6.2 Application of the evaluation model

The second stage of this analysis consists of describing the procedure realized within the decision aiding process, applying the proposed evaluation model. This stage includes the following steps: i) obtaining the data; ii) parameters definition for the proposed aggregation procedure, which implies the definition of thresholds and weights; and iii) modeling and generating the final recommendation. We used the Diviz software to implement the ELECTRE III method (Weistroffer & Li, 2016; Bigaret & Meyer, 2019).

Determination of information. The information used in this study was obtained from the credit manager and the data provided by the IT manager. Considering the evaluation model and the proposed method, and the information resulting from the DM discussions, the following decision matrix was reached, see Table 5.

Table 5 – Attribute table.

	Attributes				
Alternatives	f_{nd}	f_{pdd}	f_{rm}	f_{pdr}	f_{ccc}
S_a	$ 21,014.00	30	$ 53,270,397.79	41%	42
S_b	$ 15,017.00	60	$ 22,682,068.83	42%	18
S_c	$ 8,585.00	90	$ 10,606,706.42	41%	8
S_d	$ 37,124.00	365	$ 25,920,250.10	43%	21
S_e	$ 184,073.00	730	$ 74,933,516.44	35%	59

Source: Own elaboration.

The matrix in Table 5 represents each alternative's value according to the attributes defined with the DM. With the information included in this matrix, the criteria were constructed according to their type and function. Table 6 presents the performance matrix.

Table 6 – Performance matrix.

	Criteria				
Alternatives	f_{nd}	f_{pdd}	f_{rm}	f_{pdr}	f_{ccc}
S_a	0.98156	0.5	1	0.975	1
S_b	1	1	0.90728	0.95	0
S_c	1	1	0.42427	0.975	0
S_d	0.68865	1	1	0.925	0
S_e	0	0	1	0.975	1

Source: Own elaboration.

This information is necessary to formulate the concordance and discordance indexes used in the ELECTRE III method. Still, it is needed to define the thresholds and weights for each criterion.

Thresholds and weights (w). The thresholds that denote the relations of preference (P), weak preference (Q) and indifference (I) in each of the criteria determined by the DM are defined methodologically in the Research method section. To determine these thresholds that reflect the preferences of the DM in the model, we used a direct rating approach (Bouyssou et al. 2006), by creating a session interview with the DM where we asked him, on each criterion, about his feelings on the intensities he thinks an alternative a should be considered indifferent or preferent to alternative b or at which point he must impose a veto. The resulting values for these thresholds are shown in Table 7.

Table 7 – Threshold.

Criteria	q	p	*v*
f_{nd}	6000	10000	20000
f_{pdd}	15	30	365
f_{rm}	4000000	6000000	0
f_{pdr}	1%	2%	0
f_{ccc}	7	30	0

Source: Own elaboration.

The values of the threshold table were normalized, considering the upper and lower limits of each criterion. Only a veto threshold is regarded for the attributes of f_{nd} and f_{pdd}, in the other classes, the veto is considered null, leaving Table 8 of thresholds normalized in the following way.

Each criterion's importance must be determined by assigning a weight; this can be done differently. One of the most accepted and used methods has been the Simos revised method (Figueira & Roy, 2002). In this method, a set of cards is used to give appropriate value to each of the weights *(w)* of each criterion indirectly through interviews with experts in the subject. This procedure was applied to the DM obtaining the following weights, see Table 9.

The values of the thresholds and weights obtained are incorporated into the decision matrix, leaving the following decision matrix with thresholds and weights; see Table 10.

Table 8 – Normalized Threshold.

Criteria	q	p	v
f_{nd}	0.03419	0.05698	0.11397
f_{pdd}	0.02143	0.04286	0.52143
f_{rm}	0.06218	0.09327	0
f_{pdr}	0.12695	0.25389	0
f_{ccc}	0.13725	0.58824	0

Source: Own elaboration.

Table 9 – Weights.

	Criteria weights				
	f_{nd}	f_{pdd}	f_{rm}	f_{pdr}	f_{ccc}
Weights (w)	0.25	0.2	0.15	0.1	0.3

Source: Own elaboration.

Table 10 – Decision table with weights and threshold.

	Criteria				
Alternatives	f_{nd}	f_{pdd}	f_{rm}	f_{pdr}	f_{ccc}
S_a	0.98156	0.50000	1.00000	0.97500	1.00000
S_b	1.00000	1.00000	0.90728	0.95000	0.00000
S_c	1.00000	1.00000	0.42427	0.97500	0.00000
S_d	0.68865	1.00000	1.00000	0.92500	0.00000
S_e	0.00000	0.00000	1.00000	0.97500	1.00000
weights (w)	0.25000	0.20000	0.15000	0.10000	0.30000
threshold (q)	0.03419	0.02143	0.06218	0.12695	0.13725
threshold (p)	0.05698	0.04286	0.09327	0.25389	0.58824
threshold (v)	0.11397	0.52143	0.00000	0.00000	0.00000

Own elaboration.

Software modeling. Diviz is free development software that was used in this case study. It was created by the Project Decision Deck (Weistroffer & Li, 2016) and it is composed of different multicriteria methods for decision aiding. In addition, it includes ELECTRE III (Greco, Ehrgott & Figueira, 2016). The Diviz version used in this study was v17.2. Tutorials and the software can be found in the reference (Bigaret & Meyer, 2019). When a model is created in Diviz v17.2, the corresponding modules are selected together with the input data of table 9. Subsequently, the declaration of each of the files containing the alternatives, criteria, weights, and decision matrix was made in a separate file with the extension "*.csv." The next step was to identify the modules belonging to ELECTRE III that incorporate aggregation and exploitation phases, including concordance and discordance, the matrix of credibility, distillation, and the ranking.

Finally, we use a Hasse diagram module to create a graph of the ranking of alternatives and some connection modules. Once the diagram and connections between the various modules have been completed, the modeling is performed; the program begins to run and process the information in each of the stages of the model to obtain a result for the following stages, generating the output represented by a Hasse diagram, see Figure 6. A more extensive explanation of using the diviz tool to assist the analyst in the decision aid process can be seen (Bigaret & Meyer, 2019).

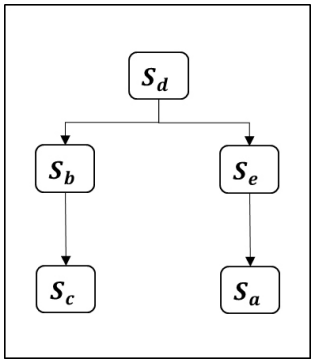


Figure 6 – Hasse diagram representing the ranking of the alternatives in decreasing order of preferences.

Source: Own elaboration.

The resulting Hasse diagram is a simplified graphical representation of the ranking; it contains a finite set of ranking alternatives, excluding redundant information like cycles and edges in the graph. It is understood that the ranking is reflexive and transitive. The result of the evaluation model is a partial order that can be interpreted as the alternative S_d is preferred to the alternatives S_b , and S_c, at the same time, the alternative S_d is preferred to the alternatives S_e and S_a. Besides, the alternatives S_b and S_e are incomparable to each other, in the same way, the alternatives S_c and S_a.

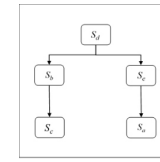
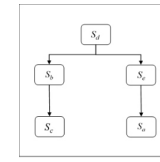
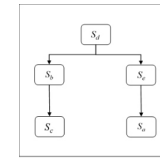
6.3 Sensitivity analysis

The output of the evaluation model is consistent with the model itself. However, this model does not assure that the result is consistent with the client's preoccupations or the DM. Therefore, bore making a final recommendation, caution should be concerned with the *sensitivity, robustness,* and *legitimacy* of the evaluation model's results (Bouyssou et al., 2006). With that purpose, two tests were realized considering possible scenarios in conjunction with the DM, aiming to show that the solution does not depend mainly on the information of the thresholds but the preferential information of the evaluation model.

The first test measures the *result's sensitivity*, considering minor variations in the thresholds values; it consists of performing three runs doing small increases or decreasing some thresholds value. Table 11 shows the values of the parameters of test number one. Only the bold values were modified for each run and the Research method section; the thresholds values must be normalized to model them in Diviz v17.2. From the Hasse diagram obtained in each run, it can be concluded

that the changes in the parameters set in test one had no significant impact on the final result since the rankings obtained showed no difference from the original ranking. The second test measures the *robustness* of the outcome, considering significant variations in the thresholds' values; it consists of performing three runs doing increases or decreases of greater magnitude in some threshold values. Table 12 shows the values of the parameters for test number two.

Table 11 – Values for the parameters of test one.

Test one parameters		**Criteria**					**Proposed Ranking**
		f_{nd}	f_{pdd}	f_{rm}	f_{pdr}	f_{ccc}	
Run 1	**wights (w)**	0.25	0.20	0.15	0.10	0.30	
	Indifference (q)	**5750.00**	15.00	**$ 3,900,000.00**	0.01	**6.00**	
	Preference (p)	**9750.00**	30.00	**$ 5,900,000.00**	0.02	**25.00**	
	Veto (v)	**22500.00**	365.00	0.00	0.00	0.00	
Run 2	**wights (w)**	0.25	0.20	0.15	0.10	0.30	
	Indifference (q)	**5500.00**	7.00	**$ 3,800,000.00**	0.01	7.00	
	Preference (p)	**9500.00**	20.00	**$ 5,800,000.00**	**0.03**	**20.00**	
	Veto (v)	**25000.00**	300.00	0.00	0.00	0.00	
Run 3	**wights (w)**	**0.20**	0.20	0.15	0.10	**0.35**	
	Indifference (q)	6000.00	**20.00**	$ 4,000,000.00	**0.02**	**15.00**	
	Preference (p)	**11000.00**	30.00	**$ 6,900,000.00**	**0.03**	30.00	
	Veto (v)	20000.00	365.00	0.00	0.00	0.00	

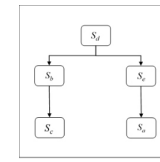
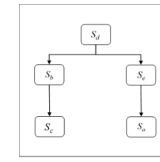
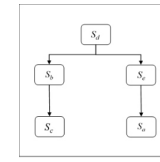
Source: Own elaboration.

From the Hasse diagram obtained for each run, it can be concluded that the changes in the parameters set in test two had no significant impact on the result since the rankings obtained showed no adjustments from the original ranking. This represents that the model remains stable in possible substantial changes in the values of the parameters. Furthermore, both tests were validated in conjunction with the DM considering potential scenarios, which helped measure the *result's legitimacy* by checking the DM's acceptance.

7 DISCUSSION AND MAIN CONTRIBUTIONS

The accounts receivable strategies problem is a real multicriteria decision problem, where at least two criteria are in contradiction. The accounts receivable strategies problem solved solely by operational performance or managerial performance may not be the right choice for the credit manager. Thus, the proposed model could balance these approaches and provide a more significant

Table 12 – Values for the parameters of test two.

Test one parameters		Criteria					Proposed Ranking
		f_{nd}	f_{pdd}	f_{rm}	f_{pdr}	f_{ccc}	
Run 1	**wights (w)**	0.25	0.20	0.15	0.10	0.30	
	Indifference (q)	**2000.00**	15.00	**$ 3,000,000.00**	0.01	7.00	
	Preference (p)	**6000.00**	30.00	**$ 4,000,000.00**	0.02	30.00	
	Veto (v)	**25000.00**	365.00	0.00	0.00	0.00	
Run 2	**wights (w)**	0.25	0.20	0.15	0.10	0.30	
	Indifference (q)	**3000.00**	**20.00**	**$ 3,800,000.00**	**0.01**	**20.00**	
	Preference (p)	**5000.00**	30.00	**$ 5,800,000.00**	**0.03**	**45.00**	
	Veto (v)	**30000.00**	**250.00**	0.00	0.00	0.00	
Run 3	**wights (w)**	0.25	0.20	0.15	0.10	0.30	
	Indifference (q)	**9000.00**	**20.00**	**$ 7,000,000.00**	0.01	**15.00**	
	Preference (p)	**12000.00**	30.00	**$ 10,000,000.00**	0.02	30.00	
	Veto (v)	20000.00	365.00	0.00	0.00	0.00	

Source: Own elaboration.

overall performance. The main managerial implication of this work is to relate account receivable decisions to operational and financial criteria. This allows the recovery of the company's receivables not to overlap with the level of service offered to customers.

The ranking obtained from the evaluation model allows creating a hierarchy between accounts receivable strategies adjusted to the DM preferences to determine the types of accounts with greater, equal, or less relevance to focus efforts on the search to increase the debt's recovery. These efforts involve restructuring the accounts receivable strategies, concluding with the need to create a call center. Therefore, the final recommendation consists of supporting the decision-making on the initial size of the telephone call center and its later stages.

It is proposed to start the project considering the accounts receivable S_d with 37,124 debtors and the call strategy for payment agreement, expecting to raise $25,920,250. Afterward, it is proposed considering the accounts receivable S_b or S_e and then the accounts receivable S_c or S_a since they show an incomparability for the difference between their number of debtors and the complexity linked to the payment due days and the percentages of debt recovery. Accounts receivable S_b involves adding 15,017 debtors, with payment reminders and call to reference strategies, with this expected to raise $22,682,068. The next thing will be to select accounts receivable S_c with

8,585 debtors, adopting payment reminder strategies, and calling references searching to raise $10,606,706.

Consider the accounts receivable S_e involves adding 184,073 debtors to the call center using the new call strategy to formalize a payment agreement; with this, one would expect to raise $74,933,516. Account receivable S_a involves adding 21,014 debtors to the call center with the payment reminder strategy, with which it is expected to grow $53,270,397. It can be considered logical to select the accounts receivable S_e and S_a with higher debt to start waiting for more considerable debt recovery. Still, the data obtained for the study shows us that these types of accounts receivable have many debtors that are much higher than the other types. Therefore, starting with these accounts receivable strategies would imply a more significant cash investment and higher risk.

Because of this case study, some measures to optimize the internal control of account receivable were implemented in the company: setting up a special credit management department, attaching importance to contract signing, clarifying the rights and responsibilities of management of account receivable, smoothing information channels, and applying the performance appraisal mode of the balanced scorecard. Also, the company hired an independent solid accounting firm to review and evaluate whether the internal control system of the enterprise's account receivable was perfect, whether if there were loopholes, whether if the enforcement of the system was appropriate.

Finally, it is worth mentioning that improving the collection of accounts receivable addresses different issues and approaches, from analyzing the collection culture to defining an order of accounts receivable considering the preferences of the DM. In any measure, it is complex because they take social, statistical, economic, and cultural aspects of the environment in which the collection is carried out. There are different approaches and methodologies to address these problems, which are mentioned in the literature review presented in section 2. Mainly, the difference between these approaches is that some focus on analyzing the change after applying a method. At the same time, the other seeks to examine the circumstance to define the difference that will be made and the result that is expected to be obtained. These approaches are different by nature; thus, it is not possible to compare the approaches found in the literature.

8 CONCLUSIONS AND FUTURE RESEARCH

This study aimed to offer a novel procedure for integrated assessment and comparison of accounts receivable strategies in a Mexican regional company dedicated to furniture sales on credit, using a Multi-criteria Decision Aiding Approach. The proposed procedure for multicriteria ranking of accounts receivable strategies uses the ELECTRE III method.

This study's multicriteria method to rank the company's accounts receivable strategies is both practical and adequate. In addition, the proposed multicriteria assessment framework can provide a rationale for interested stakeholders, including public and private companies, financial institutions, businesspersons, and academics.

The application presented in this study underscores the applicability of the outranking approach to real-life financial problems in a multicriteria decisional context. Thus, this study contributes to a growing body of application-based knowledge in the management science area.

In this paper, we have addressed multicriteria ranking with a set of accounts receivable strategies. This contribution's primary methodological added value is to propose a multicriteria model that can be applied to solve this problem.

In the future, we intend to use an empirical approach to test the ELECTRE III method on a medium set of decision criteria with a wide variety in their structure to highlight the method's efficiency. Validation tests will be conducted on both artificial and real data sets. We would like to ascertain how close the prescriptions from our method come to decision-maker solutions. It will also be essential to explore the limits of this approach by finding the top size of decision criteria and accounts receivable strategies within instances that can be solved with acceptable performance.

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