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Research Article

# Using Multicriteria Decision Methods for Evaluation and Prioritization of Investment Projects in Mexico: Literature Review

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## Abstract

This paper presents and examines the multi-criteria evaluation methods used for the evaluation and prioritization of investment projects financed with competitive funds. The main objective is to obtain conclusions about the best possible evaluation of the decision-making problem multi-criteria related to solid financing alternatives and consistent with the needs of the rural population. From the previous works it is clear that the paradigm shift Chapingo ongoing began in the 1990s. The new paradigm is characterized by the use of methodologies that include more than one objective as an evaluation criterion, both qualitative and quantitative. This objective makes the evaluation of investment projects a process multidimensional, with clear evidence that multicriteria decision-making models offer better answers to current assessment requirements.

**keyowrds:** Project Evaluation; Fuzzy Logic; Linear Programming; TOPSIS; AHP

## Introduction

Multicriteria evaluation defines complex problems in which various decisions and criteria [1]. The selection goes beyond the simple solution based on economic aspects [2], which have often been the most widely used methods despite the existence of numerous evaluation techniques [3-7], conclude that the Net Present Value (NPV), the Rate Internal Return (IRR) and Benefit-Cost Ratio (RB/C) remain the most widely used methods to evaluate and select investment projects. This reinforces the conclusion of [8,9] that in the evaluation and selection of projects the quantitative monocriteria perspective. According to [10], currently the selection of projects with funds Competitive projects lack a technical model that selects the best investment alternatives and the that apply a model, are mostly of a monocriteria nature (they only evaluate economic criteria) or technicians) and a minority apply multi-criteria decision models. The most applied models are Linear weighting (also called scoring) and sometimes the method called Both methods have a series of weaknesses that do not allow determining which are the best. investment proposals, its main weakness is that there is no technical study available for the assignment of weights for each criterion used in the evaluation. This assignment, in all cases, It is carried out in a completely intuitive way by the program's decision makers. Consequently, an objective analysis of multi-criteria decision methods (MDMC) can provide relevant information on the optimal selection of investment projects. The characteristics, Scope and trends are elements that can reveal whether the methods used during the last 30 years guarantee a solid and consistent evaluation and whether these procedures are adequate to: evaluate a large number of criteria and sub criteria to a large number of alternatives, using both quantitative and qualitative criteria. Likewise, it is expected that these methods do not yield alternatives with the same rating and that the entry into the evaluation of new alternatives does not involves generating a new application of the method and, above all, allows for the selection of alternatives closer to the ideal solution..

## Research Methodology

As detailed in previous paragraphs, the methods used in Mexico are inefficient. for complex decision problems, especially in those cases where we encounter quantitative - qualitative information and that evaluating the proposals in a comprehensive manner is crucial to determine the success or failure of the implementation. For the study of the MDMC applied in Mexico, the data were obtained through review by the keywords: "Selection", "Multicriteria", "Projects" and "Mexico" mainly, publications in virtual databases such as EBSCO, Science Direct and Jstor, finding 21studies specifically related to the application or development of MDMC for the selection of investment projects in Mexico.

## Multicriteria selection models

According to [11], MDMCs are divided into two branches: multi-attribute decision making, which considers a limited number of alternatives for evaluation and decision making multi-objective, which identify the best alternative from an infinite set of alternatives under a set of constants. For their part, [12,13] state that the Multicriteria methods are divided into two groups: 1) methods based on value theory and, 2) classification methods; while classified the MDMC methods into four groups: distance, outranking, priority, utility and mixed. The main methods, expressed in their original acronyms, are the following:

## Distance Methods

They are designed to identify non-relegated solutions that are closer to an ideal solution by some measure of distance, whether metric, geometric or relative. The best known methods are Commitment Programming (CP), Cooperative Game Theory (CGT), Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) y Composite Programming (COP).

## Outranking or Superation Relationship Methods

Created in the 1960s, they are relatively simple instruments to obtain a preselection of very good alternatives wide. The size of the set of efficient solutions is reduced by means of a partition into a subset of "more favorable" alternatives and another of "less favorable" ones. A The outperformance relationship constitutes a model of preference aggregation, and represents the particular case of two alternatives that are "incomparable". It consists of admitting for any pair of alternatives that one "surpasses" the other when they are satisfied a condition of agreement and a condition of disagreement. The main methods of this type its Elimination And Choice Translating Reality (ELECTRE) and Preference Ranking Organisation Method for Enrichment Evaluation (PROMETHEE).

## Priority or utility methods

They include a set of decision tools that are They feed on utility functions and/or vectors by criteria, which when integrated generate a ranking of prioritization of alternatives. It includes the most basic methods of Linear weighting type Scoring such as the Weighted sum model (WSM) and the Weighted product model (WPM), others focused on the generation of utility functions such as the Multi Attribute Utility Theory (MAUT) or networks of relationships between criteria, such as the Analytic Network Process (ANP), to hierarchical models, whose best known representative is el Analytic Hierarchy Process (AHP).

## Mixed Methods

In these cases the alternatives are compared simultaneously with the set of all criteria. To do this, a preference matrix must be established derived from a payoff matrix representing the decision maker's preferences. Then the preference matrix into an incidence matrix based on the threshold levels obtained. Finally, satisfaction, agreement and discordance indices are calculated. normalized, calculating the total priority of each alternative by combining these. The best known method of this type is Multicriterion Q-Analysis (MCQA). In addition, the applied techniques can be classified with respect to the composition of their variables and the consideration of uncertainty or risk. In this way, discrete methods emerge and fuzzy or diffuse logic methods. Finally, a common classification is relates to the type of decision faced, the most common being Analysis Multicriteria (AMC) and Multicriteria Evaluation (EMC). These methods have advantages and disadvantages, for this reason developed a model called CODAS (Combinative Distance-based Assessment), which adds characteristics not considered by other MDMCs. According to Mardani et al., (2015), for the best response of these methods, some authors have combined different tools based on the previously developed multicriteria methods, starting from their modification and applying Fuzzy sets are obtained from methods such as COPRAS, ARAS, EDAS and WASPAS.

## Results and discussion

According [14], initially the elements that intervened in the process of The selection of projects was easily manageable due to its dimensions (budget, number of candidate projects, time period, among others) and the analysts made the decisions of what projects select intuitively, gathering the largest amount of information available of each of the alternatives (candidate projects) and with it make a decision, since it is considered that there were no models that could summarize or aggregate all the information and provide a relevant conclusion. Although this way of acting was maintained for many years, the entities have evolved. increasing its size and, therefore, its resources and needs, which has led to the decision makers seek a rational strategy when determining which projects are the that must be selected and executed. This results in the search for measurement scales common that allowed the comparison between alternatives, giving rise to the study of the first selection and classification techniques among candidate projects. In 1980 [15] linear programming was applied for the first time to Evaluate the projects individually based on economic aspects, carrying out from this criterion an ordering of them to, subsequently, select those projects in the order previously established, until the available budget is exhausted. The technique used by these The authors take into account the money flow movement that each project is expected to have over time. throughout its life cycle. It was not until 2006 that MDMCs were used for the first time. select projects, with the AHP method being the most widely used. Among the authors who have used and applied this method are [16-19], whose results highlight the objective prioritization of the alternatives and the weighting of the quantitative and qualitative selection criteria, but also the weaknesses of this model posed, such as performing new calculations when a new alternative is added, which in the short term, the level of confidence of the results decreases, in this case the finding most important of [20].

Table 1: shows the methodologies used by Mexican researchers interested in the selection of projects, which demonstrate over time the level of complexity achieved and the different combinations of models to correct the deficiencies determined in the model economic. Another of the investigations that stand out is the one carried out by [21] who evaluate agricultural tractors using the TOPSIS technique to generate the model, which was applied to several Tractor selection case studies, involving decision-making groups consisting of agricultural producers. They conclude that the model is efficient, easy to apply and has wide acceptance by agricultural producers. In this same year,) [17] present a procedure to prioritize tourism projects using AHP, applying economic and technical selection criteria. We also found a methodology applied by that, based on an evaluation of resources of the Sierra de Nanchititla State Park in the State of Mexico (PESN), applies the Scoring methodology for the hierarchization of criteria on which products must be worked on tourism that would generate sustainable economic alternatives [22] for their part, discuss the advantages of multicriteria modeling and subjective approach associated with solving problems of project, program or policy portfolios of the public sector. On this basis, a definition of the best solution to a problem is presented distribution of public resources and its representation as a multi-objective optimization problem. They describe a solution method using multi-objective evolutionary algorithms, in which incorporate multi-criteria decision preferences using the ELECTRE method. The proposal It is exemplified with good results in real-size cases, which illustrate selection methods social assistance programs and basic research projects. Another application that evaluates public investments is the one proposed by [19], which uses the AHP method to respond to the need for the Municipal Drinking Water Service and San Luis Potosí, Mexico Sewerage System to carry out an adequate prioritization of the projects components of the investment portfolio, which are programmed in the Operational Program [21-30].

Table 1: Methodologies applied by Mexican authors for the Selection of Projects using MDMC.

| Number | Publication | Method | Objective function or Criteria | | | |
|---|---|---|---|---|---|---|
| 1 | Garcia, A., and Chalita, T. (1980) | Linear Programming X | Economic | Technical | Social | Environment |
| 2 | García, et al., (2006) | AHP | | | | |
| 3 | Alcaraz and Arellano (2009) | TOPSIS | XX | | | |
| 4 | Franco et al. (2009) | AHP | XX | | | |
| 5 | Martínez et al. (2010) | Scoring | | X | | X |
| 6 | Rivera, Mendoza and Servin (2010) | AHP | | X | | X |
| 7 | Fernández, et al., (2011) | ELECTRA | X | | X | X |
| 8 | Villegas (2011) | AHP | XXX | | | |
| 9 | Mojica and Alcaraz (2011) | TOPSIS | XX | | | |
| 10 | Benítez (2013) | Scoring | XX | | | X |
| 11 | Rojas (2014 | AHP | XX | | | |
| 12 | Ramirez, Flores and Vargas (2017) | AHP | XX | | | |
| 13 | Hernández et al., (2019) | AHP | | X | | |
| 14 | Perez and Martinez (2020) | TOPSIS | XXXX | | | |
| 15 | Ayala, Valdes and Romo (2021) | PROMETHE | X | | XX | |
| 16 | Cobacho et al., (SD) | Programming objective | X | | X | |

Annual and Budget of each management for its respective execution. In this sense, the author concludes that the model developed using AHP is a very useful tool for decision making. decisions, since it is easy to understand and apply, it also allows for having a support of the evaluations and selections made. The method also allows the incorporation of more criteria and more alternatives; however, the more these variables increase, The model will present greater complexities, which at some point could lead to confusion [10], for their part, proposed a methodological proposal that uses two Multi-criteria decision tools: AHP and TOPSIS for selecting investment projects in the Mexican rural environment. The model defines a series of criteria that are considered important when from the evaluation of investment proposals and through the AHP tool they weigh the criteria quantitative and qualitative and, to select the best proposals, they use the tool TOPSIS. And they conclude that, although the model improves the comprehensive evaluation process of the investment proposals, adds complexity to the procedure, requiring the evaluator to have greater amount of time spent in decision making. Finally, in 2021 [23,24] prioritize different production systems associated with coffee and avocado cultivation, through two scenarios: financial and multi-criteria. In the financial included monetary measures, with which the cost-benefit ratio was calculated and in multi-criteria, the criteria of investment need, employment, management, carbon and nitrogen in plant biomass, biomass and diversity of soil macrofauna. These criteria were analyzed using the PROMETHEE method; through which an ordering of prioritization. The results of the analyzed works determined that there is evidence of better performance The authors conclude that the MDMCs do not enjoy a sufficient level of implementation, given that Their use adds complexity for decision makers. They are also another gap in the models applied in Mexico using non-standardized Checklist and Scoring models, are extremely simple and do not obtain adequate prioritization.

## Conclusions

In response to one of the great uncertainties that the government has in the selection of projects investment, always seeking to obtain greater profitability and less risk, a exhaustive search of the different applied studies that have been carried out in Mexico for the evaluation and selection of projects using multi-criteria decision models. By carrying out a review of the bibliographic material, during the course of this research, it was possible find that most of the studies were conducted using linear programming and AHP, which sought to achieve the same objective of selecting investment projects. In a comparison between the 21 investigations found with the same purpose of maximizing the profitability, we find that Net Present Value is the criterion that receives the most attention. from the conclusions drawn from the work carried out with a combination of AHP models- TOPSIS, or AHP- PROMETHE is that they solve the problem of decision making when there is a broad portfolio of alternatives. Regarding software development applying different methodologies, it has not been widely studied. Considering that the cause of this is the little information that we can obtain by performing exhaustive research on the subject in Mexico. In the preparation of this study, we wanted to do a clear search for information where They propose the methodologies that were developed in Mexico for the selection of optimal projects, so that the different theories applied and their results could be known at a general level. However, given the theme of this research, it would be interesting to continue along this line to be able to find studies with new methodologies that allow us to define more precisely and accuracy the process to be carried out for the selection, especially those that refute the theories traditional assessment methods.

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