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Analysis of the Countries' business attraction with the ELECTRE-III method

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Abstract. Attracting foreign investment is essential for the competitiveness and prosperity of nations. When deciding where to invest, an investor may be interested in considering specific criteria for investing or doing business and preferences for those criteria. In the same way, when evaluating the situation of a country to attract investment, consider different aspects to determine its ease of doing business. The MultiCriteria Decision-Making (MCDM) methodology is suitable for evaluating nations according to their ease of doing business due to the multifactorial elements of each nation. This work applied the ELECTRE-III method; it evaluated 190 nations based on the decision-maker's preferences, giving different importance to the ten criteria considered in the World Bank's Doing Business 2020 study. The results with this methodology show better-positioned nations in the ranking compared to the report presented by the World Bank Group.

Keywords: World Bank, Doing Business, business attraction, ELECTRE-III, multicriteria ranking, MCDM

1. Introduction

When developing a project to invest in a country or city, a fundamental criterion to be considered by decision-makers is the geographical location where it will be implemented. However, even considering its importance, there are other things to consider. The decision-makers tend to value additional aspects, such as security and legal elements related to the formalization of the investment, among others.

Similarly, the countries and their governments may be interested in attracting investment, requiring knowledge of the investors consider consistent with a competitive environment such as the current context. In this sense, both government institutions and investors have the possibility of analyzing information published by international organizations that evaluate nations in various areas, such as economic development, poverty rates, and inflation, as applied in Gryshova et al. [21]. Authors assess Ukraine's competitiveness based on information generated and published by the World Bank's Doing Business, the Corruption Perceptions Index, the Human Development Index, and the Global Competitiveness Ranking.

However, various factors influence investment attraction and decision-making in investment sites. Borissova et al. [6] mention that some factors are macroeconomic stability, trade policies, and even aspects of technology and financial security, among others. In this sense, multiple decision criteria are involved when choosing a place to invest, even making a distinction by city or region, including aspects related to direct and indirect competitors, target market, and subjective interests of decision makers.

In decision-making, obtaining all the information regarding the aspect is necessary to choose the best option. In this sense, various institutions carry out studies and generate information on evaluating nations and regions in different areas; these data are quickly available through digital portals and open databases. An international institution that carries out such measurements and evaluations through different programs is the World Bank Group, allowing using the available information, whether by business people, academics, researchers, or the governments themselves, for analysis processes and decisions, such as investigations on investment sites [26], correlational studies for the investment of small and medium-sized enterprises [14] and credit risk assessment [29], to name a few examples.

Regarding the evaluation of countries according to their ease of attracting and implementing investment projects, the World Bank Group periodically prepares reports on the ranking of nations according to their ease of investing through the Doing Business report [19], which evaluates 190 nations considering ten criteria related to the ease of doing business, publishing a ranking of the nations evaluated. The criteria considered in the World Bank study are the number and cost of the procedures necessary to set up a company, legal and professional records, and the minimum amounts to open bank accounts and start operations.

Other indicators evaluated by the World Bank are ease of processing construction permits, installation of electrical infrastructure, purchase and registration of properties, obtaining bank loans for foreign entities and tax payment. On the other side, it is essential to consider the government policies for protecting foreign and minority investors, import and export costs and times, laws regarding procedures and judgments for contract compliance, and the applicable legal framework for the alienation of assets due to debts.

In attracting foreign investment problems, it seems pertinent to approach it from a methodology that considers multiple decision criteria and the decision-maker's point of view. In this sense, the MultiCriteria Decision-Making (MCDM) methodology considers a wide range of methods with different approaches to address decision problems involving multiple criteria and the decision maker's preferences, resulting in solution proposals that match the view and value's system of the decision-maker.

The paper aims to answer the research question, how to rank the countries regarding different attributes to attract investment?. This research analyzes the countries' attractiveness for investment. The information published by the World Bank on its 2020 edition Doing Business microsite is analyzed. Here 190 countries are valued with 10 decision criteria established by the World Bank Group. The problem is approached from a multicriteria decision analysis (MCDA) methodology, applying the ELECTRE-III method. One of the main differences presented by the World Bank in its Doing Business report is that the proposed method allows the possibility of including the decision-maker's preference in the decision model to rank countries according to the country's situation to attract investment.

The main contributions of the paper are listed as follows:

- Analysis of the attractiveness of countries for investing with a multicriteria decision analysis methodology.
- Application of the ELECTRE-III method from the outranking approach to model the decision-maker preferences in the decision problem.
- The prioritization of countries with the best indicators to attract investment.

The paper is organized as follows. Section 2 presents a theoretical and conceptual description of studies of multicriteria decision-making methods with data generated by international institutions. Section 3 presents the methodology implemented to analyze the country's attraction. The discussion of the results is shown in Section 4. Finally, Section 5 presents the conclusions of the research.

2. Related Work

Various entities generate a large amount of data through surveys and censuses, the information is presented freely through repositories and digital data banks and free access, which can be used to carry out studies, calculations, estimates and make decisions in different areas, such is the case of the World Bank and Global Countries Competitiveness Rating.

In particular, the World Bank Group presents the microsite Doing Business, whose reports present information resulting from studies that they summarize, with the possibility of downloading and using them by the same countries referenced in the report as part of the decision-making process in relation to their government policies and mechanisms to attract foreign investment, as well as by companies or corporations interested in investing or establishing subsidiaries in other countries according to their expansion policy [20].

Using information such as that published by the World Bank can be considered one of the aspects that experts take to carry out a decision, such as choosing an investment site; However, other factors may not be included in the studies carried out by the institutions responsible for collecting information, but which have equal or greater weight for the experts since they have to do with their reality and the achievement of their objectives, such as the collection of funds and macroeconomic criteria or other aspects that can be considered as part of the decision maker's preferences. A decision problem can be approached from different approaches, applying tools that support decision-making, which offer the possibility of considering the decision maker's preferences, such as multicriteria decision-making methods (MCDM). In this sense, various authors have analyzed decision problems applying multicriteria methods; such is the case of Álvarez et al. [4], who analyze the innovation capacity in Mexico using the ELECTRE-III multicriteria method, considering many criteria involved and also the decision-maker's preferences, presenting as results a ranking of the 32 regions of Mexico according to their innovation capacity, valuable information for a decision process in this regard.

Continuing with the relevance of applying multicriteria methods in various decision problems, Álvarez et al. [1] and Muñoz-Palma et al. [25], evaluate the competitiveness in a country through a distinction by region, differentiating regions with a higher and lower competitiveness index. In both studies, ELECTRE-III was applied in a hierarchical version and through the conformation of composite indices, respectively. The results of these

studies provide the opportunity to analyze aspects of the competitiveness in Mexico, with the purpose of a possible application of decisions regarding public policies and attraction of investment capital in regions of the country.

The ELECTRE-III method has been applied in various decision problems, where specific characteristics are identified, such as heterogeneous measurement scales in the criteria to be evaluated and taking into account imperfect aspects of the construction of the same criteria, as well as qualitative information in their performance and their translation into quantitative information [16]. In the same way, this multicriteria method is used for group decisions in both governmental and private problems [3] [22], this being relevant for its use in problems such as the selection of research sites of investment, with information from institutions such as the World Bank Group, whose construction of the criteria to be evaluated tend to have characteristics such as those previously mentioned.

Regarding the studies that use information from the World Bank with multicriteria methodologies for decision-making, Soares-Silva et al. [29] present the credit risk assessment of bank bonds applying the Rough set method. This idea is also found in a study by De Lima Silva et al. [9] when considering the linguistic assessments converted into scales for the criteria, each scale being a discrete value for their weights.

In the same way, research has been presented with algorithms and models to address decision-making problems, such as generating proposals for places to do business, mainly for small and medium-sized companies, and analyzing the information presented by Doing Business, such as the one presented by Borissova. et al. [6], where group decision-making and weighted sum and simple additive weighting models are applied, the method used is similar to that used by the World Bank.

It should be noted that the studies presented by these authors [29][9][6], coincide with the present investigation when using multicriteria decision-making methods; however, a difference What is notable with our proposal is that the decision-maker's preferences are not taken into consideration, ignoring the possible needs of the decision-maker concerning the objectives to be achieved, or simply an adaptation of the model to be used by the regions to be analyzed in the problem, giving greater weight to specific criteria.

Analyzing the information presented by Doing Business with other multicriteria analysis methods allows obtaining new rankings under specific evaluation criteria, detecting weaknesses in the report published by the World Bank, considering that each dimension evaluated has the exact weighting and that possibly the indicators evaluated by Doing Business, do not reflect the particular reality of each nation [28]. The above is intended to be addressed in this investigation with a multicriteria methodology where the decision-maker's preferences are considered holistically, correcting one of the possible weaknesses detected in the World Bank ranking.

The use of digital databases makes it possible to implement decision-making methodologies proposed in studies and research projects, as well as to generate public policy proposals in different regions of the world, based on different decision-making problems [13] [14][18], simulating scenarios in which the expert is not willing to provide any information about their holistic preferences.

For this analysis, data from the World Bank, from the Doing Business [19] repository, was used to develop a ranking of the viability of nations to do business under two different techniques to those presented by the World Bank Group, using an ELECTRE-III multi-

criteria method, which has not been used to analyze this information, in order to compare the results and analyze the similarities and differences.

3. Methodology

The current research analyzes the information on Doing Business in its 2020 edition. Doing Business publishes information in five general aspects, divided into ten criteria that classify economies according to the ease of doing business [19]. In the present investigation, an experimental methodology was implemented, which consisted mainly of applying a multicriteria method for decision-making (MCDM), considering the preferences of the decision-maker, being a method different from that used by the World Bank in its Doing Business, where there is no preference distinction towards the relative importance of the criteria to carry out the resulting ordering.

The analysis of the valuation of countries is carried out by applying the ELECTRE-III, MCDM method. The methodological process to analyze countries' situation is depicted in Figure 1. It is carried out mainly in three stages. In Stage 1, the multicriteria decision-making problem is defined. Here, the decision criteria and alternatives are defined. The valuation of alternatives by each criterion corresponds to the performance matrix of the countries. The defined elements of Stages 1 and 2 correspond to the database from Doing Business [19].

Stage 2 corresponds to the method's parameters definition. The ELECTRE-III method requires the relative importance of criteria (w), indifference (q), preference (p), and veto (v) thresholds. Each of those parameters is defined for each criterion. The application of the MCDM method is carried out at this stage. The output is a ranking of alternatives.

Stage 3 corresponds to the analysis of the countries generated in the last stage. If the decision-maker does not agree with the result, she/he can go back to previous stages to modify her/his preferences until the resulting ranking matches her/his point of view.

Table 1 shows the decision criteria to analyze economies. Here, it is considered regulations that affect companies in all their stages, the creation of the company, obtaining a location, access to financing, management of daily operations, and operation in a secure business environment. The data concerns 190 economies around the world.

Table 1. Criteria for Evaluating the Ease of Doing Business

Criteria	Description
g1	Starting a business
g2	Dealing with construction permits
g3	Getting electricity
g4	Registering property
g5	Getting credit
g6	Protecting minority investors
g7	Paying taxes
g8	Trading across borders
g9	Enforcing contracts
g10	Resolving insolvency

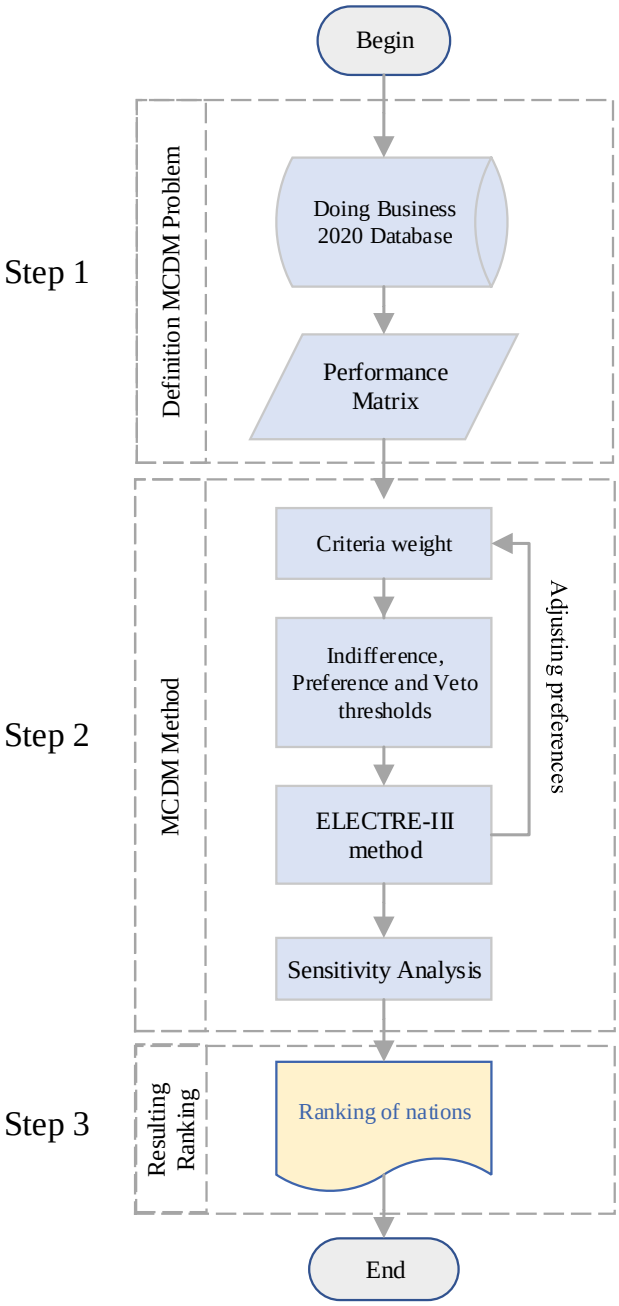

Fig. 1. Methodological process to analyze countries' situation

The ELECTRE-III method is applied to evaluate countries' performances regarding their ability to attract investment and compare each one against the others. The method is described as follows in the next section.

3.1. The ELECTRE III Method

ELECTRE III is an outranking method that compares each pair of alternatives in the $(a_i, a_l) \in A \times A$ set to assess the credibility of the assertion "action a_i is at least as good as action a_l", denoted as $a_i S a_l$. The evaluation of the assertion considers three aspects: a) the indifference and preference thresholds defined for each criterion, b) the degree or coefficients of importance attached to each criterion and c) the possible difficulties of relative comparison of two actions when one is significantly better than the other on a subset of criteria, but much worst on at least one criterion from a complementary subset.

The aggregation phase. In the aggregation phase the ELECTRE III (EIII) constructs a fuzzy outranking relation expressed as $\sigma(a_i, a_l)$ [27]. EIII constructs the comprehensive concordance index from the partial concordance index.

$C_j(a_i, a_l)$ is the partial concordance index, a fuzzy measure that evaluates if "action a_i is at least as good as action a_l" on the criterion g_j, using the DM's preference defined in the indifference q_j and preference p_j thresholds for the criterion g_j. The concordance index is one when the difference between criteria is very small, and it is cero when the difference is enough from the DM's point of view (see Equation 1).

$$C_j(a_i, a_l) = \begin{cases} 1, & \text{if } g_j(a_l) - g_j(a_i) \leq q_j, \\ \dfrac{p_j - [(g_j(a_l)) - (g_j(a_i))]}{p_j - q_j} & \text{if } q_j < g_j(a_l) - g_j(a_i) < p_j, \\ 0, & \text{if } g_j(a_l) - g_j(a_i) \geq p_j. \end{cases} \tag{1}$$

The resulted value of the partial concordance index is a fuzzy number that supports the asseveration "a_i is at least as good as a_l on criterion g_i". The values 0 and 1 are the case of no doubt about the asseveration. When the difference between alternatives increases, the asseveration loses credibility. The partial concordance index represents the credibility of the asseveration for each criterion as a fuzzy number (see Figure 2). However, no fuzzy operators are applied.

$C(a_i, a_l)$ is the comprehensive concordance index for each $(a_i, a_l) \in A \times A$, evaluating all criteria and assessing the assertion "a_i outranks a_l" (see Equation 2).

$$C(a_i, a_l) = \frac{\sum_{j=1}^{n} w_j \cdot C_j(a_i, a_l)}{\sum_{j=1}^{n} w_j} \tag{2}$$

In case of disagreement because the decision maker expresses veto values, some criterion calculates the index of discordance index $d_j(a_i, a_l)$. The discrepancy of criterion

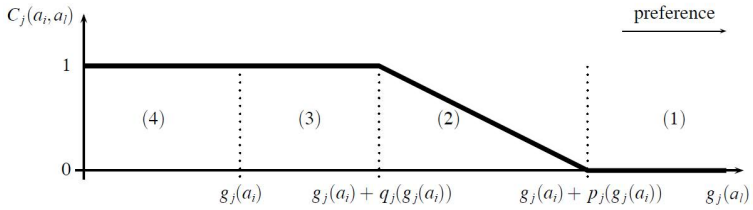

Fig. 2. Partial concordance index

g_j indicates the extent to which this criterion disagrees with the statement "a_i outranks a_l". The discordance index d_j is 0 when the difference between the two alternatives is very small for criterion g_j. As this difference increases, it is represented by a fuzzy value that increases its discordance until reaching the value of 1 when the difference between the two alternatives reaches the veto value defined for criterion g_j. Equation 3 shows the formulation of this discordance index, also represented in Figure 3.

$$d_j(a_i, a_l) = \begin{cases} 1, & \text{if } g_j(a_l) - g_j(a_i) \geq v_j, \\ \dfrac{[g_j(a_l) - g_j(a_i)] - p_j}{v_j - p_j} & \text{if } p_j < g_j(a_l) - g_j(a_i) < v_j, \\ 0, & \text{if } g_j(a_l) - g_j(a_i) \leq p_j. \end{cases} \tag{3}$$

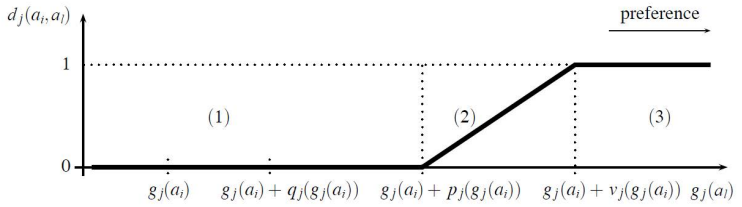

Fig. 3. Discordance index

The credibility index $\sigma(a_i, a_l)$; $(0 \leq \sigma(a_i, a_l) \leq 1)$ assesses the strength of the assertion that "a_i is at least as good as a_l", $a_i S a_l$.

$$\sigma(a_i, a_l) = \begin{cases} C(a_i, a_l), & \text{if } \overline{F}(a_i, a_l) = 0 \\ C(a_i, a_l) \times \displaystyle\prod_{j \in F(a_i, a_l)} \frac{1 - d_j(a_i, a_l)}{1 - C(a_i, a_l)} & \text{if } \overline{F}(a_i, a_l) \neq 0 \end{cases}, \tag{4}$$

where $d_j(a_i, a_l)$ is the discordant index and $F(a_i, a_l)$ is the set of pairs where $d_j(a_i, a_l) > C(a_i, a_l)$.

The exploitation phase: the distillation procedure. In the exploitation phase, the distillation procedure analyzes the fuzzy outranking relation. The distillation procedure measures the credibility of the asseveration of a_i outranks a_i with the value of $\sigma(a_i, a_l)$ and then presents a partial or complete preorder. It is generated from the descending and ascending distillation procedures, which show a complete order each.

The procedure finds $\sigma(a_i, a_l)$ corresponding with the highest value in the credibility matrix (5).

$$\lambda_0 = \max_{a_i, a_l \in A} \sigma(a_i, a_l) \tag{5}$$

Then the procedure estimates the distillation threshold function $s(\lambda_k)$ with the input parameters α and β.

$$s(\lambda_k) = \alpha\lambda_k + \beta, \tag{6}$$

where α and β are two thresholds that define the function $s(\lambda_k)$. It is a discrimination coefficient [10] for researching pairs where a_i is strictly preferred to a_l with a certain cut-off level. It is common to find $\alpha = -0.15$ and $\beta = 0.30$ as established values for the procedure.

We need to find the $\sigma(a_i, a_l)$ with the highest value in the next cut-off level $k + 1$. In each next level we shall have $\sigma(a_i, a_l) < \lambda_k - s(\lambda_k)$.

$$\lambda_1 = \max_{\sigma(a_i, a_l) < \lambda_k - s(\lambda_k)} \sigma(a_i, a_l) \tag{7}$$

In the process, the comparison of credibility degrees for pairs $\sigma(a_i, a_l)$ and $\sigma(a_l, a_i)$ is carried out. The $aS^{\lambda_1}b$ condition states a relation of power and/or weakness between alternatives. $aS^{\lambda_1}b$ if and only if $\sigma(a_i, a_l) > \lambda_1$ and $\sigma(a_i, a_l) > \sigma(a_l, a_i) + (\alpha \times \sigma(a_i, a_l) + \beta)$.

In each distillation, we shall find a reduced value of λ_k. It corresponds to a better condition to a_i is preferred than a_l for remaining subset of pairs.

Process of descending distillation

The first time the procedure begins, Step 1 and Step 2 need to performed in sequence. A iterative procedure identifies the minimum subset of alternatives that qualify for its placement in the descending complete order. The procedure finishes when all the alternatives are placed in the complete order.

Step 1: Calculate (5) as initial level to estimate the cut-off level (7) in order to identify the best remaining alternatives.

Step 2:

- **2.1** Find the highest degree of credibility with λ_k (5), estimate the next cut level λ_{k+1} (7) to find the maximum $\sigma(a_i, a_l)$ lower than $\lambda_k - s(\lambda_k)$. The subset of found alternatives with (7), are placed in the set D.
- **2.2** Calculation of power, weakness and qualification of alternatives from D. Every time a_i outranks a_l, the strength of a_i is incremented with 1 and the weakness of a_l is incremented with -1. For each alternative, the strengths and weaknesses are added together to give a final qualification score.
- **2.3** Select the alternatives with higher qualification, conforming the set D'.

The Ascending distillation performs a similar procedure in the opposite direction; the alternatives with the lowest qualification scores are assigned to the ranking's last position. The ranking is constructed from the bottom to the top.

Intersection between descending and ascending preorders

For the intersection between complete preorders, we need to find strict preferences in pairs of alternatives between preorders.

- a_i *is strictly preferred to* a_l if a_i is better positioned than a_l in at least one of the rankings, and if a_i is at least as good as a_l in the other rank.
- a_i *is indifferent to* a_l if a_i and a_l are placed in the same position (belong to same group) in the two rankings.
- a_i *is incomparable to* a_l if a_i is better positioned than a_l in one ranking and a_l is better positioned than a_i in the other ranking.

4. Results and Discussion

The Doing Business database, available on the official website of the World Bank Group, evaluates and reports 190 economies according to their ease of doing business through five general aspects, divided into ten criteria that consider all the regulations that affect investment for the implementation of a company, from its beginning, development, and end of operations [19].

The World Bank, through its Doing Business report, generates an ordering of the nations evaluated according to their global performance in the criteria determined by the same international organization, designed to evaluate their ease of investment and doing business. The ranking presented in the 2020 edition of Doing Business applies the simple average method, where it weighs all the criteria equally, giving the same weight to each of them [19].

On the other hand, in decision-making problems, such as deciding on a place to invest, the decision-maker's preferences become relevant to choosing the option to invest, turning problems of this type into decision problems with multiple criteria. In this sense, multicriteria decision-making methods (MCDM) are necessary to achieve the objectives defined for an investment site decision problem. The outranking MCDM presents heuristic approaches based on principles of agreement and disagreement, combining majority rules with respect to significant minorities and also handling uncertain and diffuse information [5].

The ELECTRE-III methodology is an MCDM outranking method, which includes the possibility of accepting qualitative as well as quantitative scales for the definition of the criteria, also allowing imperfect knowledge of the data to be modeled, an aspect that is considered by these methods with thresholds of preference and indifference required [5]. Figueira et al. [16] mention that it is appropriate to use the methods of the ELECTRE family if at least one criterion handles imperfect knowledge in its construction, which is not possible with other multicriteria methods.

Based on the above and considering the characteristics of the data that are analyzed in the present investigation, as well as the imperfect knowledge in the construction of the criteria and the definition of their importance for the expert, the ELECTRE-III outranking method was applied to determine the ranking of nations according to their ability to do business.

For applying the ELECTRE-III method, the indifference, preference, and veto thresholds were defined, as well as the weight of each of the ten criteria involved in evaluating nations. The weight of the criteria refers to the decision maker's preferences, defining whether one criterion is preferred over another.

In this research, the ELECTRE-III method was applied in two variants concerning the decision-maker's preferences, specifically regarding the relative importance of the criteria. In this sense, one instance considers the same importance for each criterion, similar to the Doing Business index. Another instance considers the different importance of the criteria regarding the expert's preference.

For this work, a local expert in finance and investment site selection was involved. The expert was assisted continually by the analyst during the definition process. The indifference (q) and preference (p) thresholds, as well as the weights (w) are the minimum parameters to be defined. This action corresponds to the elicitation process depicted in Figure 4, and it is carried out by interacting with the expert until reaching her agreement with the ranking solution. The following stages are derived from the elicitation process: definition of thresholds and weights; execution of the MCDM method, analysis of preliminary results; and adjusting the parameter if necessary.

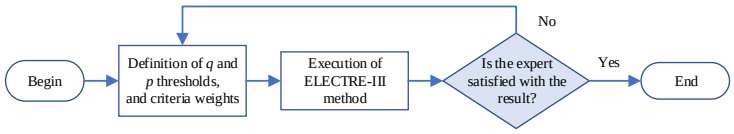

Fig. 4. Definition of parameters

The definition of the indifference (q), preference (p), and veto (v) thresholds meant a challenge for the participating expert. It was difficult to understand the meaning and express her viewpoint on this parameter. Applying the preliminary veto values resulted in solutions different from the expert's preferences. In this case, being the veto threshold (v) an optional parameter for the method used, the analyst and expert decided not to consider it in the processes presented below.

At first action, the analyst used the Simos' Revised Procedure [15]. It is a deck of cards procedure developed to support the definition of weight parameters. In this action, the expert order the criteria from the least important to the most important. The outcome is a set of weight values. The second action corresponds to explaining the meaning of indifference (q) and preference (p) thresholds. In the first instance, the expert proposed the first set of values for those parameters on each criterion. The definition by the participating expert resulted from an iterative process. Any change to the parameter values was evaluated by applying the ELECTRE-III method to generate the corresponding ranking, and the expert carefully analyzed each ranking. She worked in an interactive process, adjusting the parameter according to her ranking observations until their preferences were reflected in the solution obtained.

4.1. First instance: similar importance weights

In the first instance, the procedure simulates the point of view applied in the Doing Business index. Here the criteria are considered equally important. Table 2 list the parameters used in ELECTRE-III for the first instance. The weight value of each criterion g_i is set to 0.1. The indifference (q) and preference (p) threshold is set at 5 and 10, respectively.

Table 2. ELECTRE-III parameters regarding same importance of criteria

Parameter	g1	g2	g3	g4	g5	g6	g7	g8	g9	g10
w	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
q	5	5	5	5	5	5	5	5	5	5
p	10	10	10	10	10	10	10	10	10	10

Table 3 presents the ranking of the first ten positions considering an equal criteria weight with applying ELECTRE-III. The ten countries in the first instance ranking correspond to the same ten countries in the Doing Business index. The differences are in the position of some countries. For example, in the Doing Business report, New Zealand ranks higher than Singapore; however, the positions in our ranking are fifth and first, respectively. That is because when comparing these two nations, although the difference is minimal, Singapore is better evaluated in six of the ten criteria concerning New Zealand, which leads to deep reflection when analyzing the results when applying a different method than a simple average.

Table 3. Ten first position of the ranking regarding the same importance of criteria with ELECTRE-III

Rank	Code	Economy
1	SGP	Singapore
2	DNK	Denmark
3	KOR	Korea
4	HKG	Hong Kong
5	NZL	New Zealand
6	GBR	United Kingdom
7	NOR	Norway
8	US	United States
9	GEO	Georgia
10	SWE	Sweden

It should be noted that the results obtained with the ELECTRE-III method differ from the official ranking of the World Bank. Mainly, it is because the ELECTRE-III method is an outranking method based on a relational approach where the alternatives are compared between them, in this case the nations evaluated. The World Bank ranking uses an additive method related to the full aggregation approach in the multicriteria decision-making methodology [2]. Besides the above, the difference between results resides mainly in the

inclusion of the preference parameters necessary for applying the ELECTRE-III method (indifference, preference, and veto thresholds); that thresholds are directly involved in the final evaluation of an alternative, being determining factors in the result presented by the method, even if the criteria have the same weight (Table 2) because the performance of each nation in each criterion is compared with the values of the thresholds, having at the end a general performance of an alternative, which is compared concerning another, determining its position in the ordering.

Table 4 shows the performance in each criterion of the first five nations from Table 3. Being able to identify this information makes it possible to assess which criteria could be more relevant for a decision-maker when choosing a nation to set up a company or make an investment.

Table 4. Performance of the five first economies regarding the same importance of criteria

Economy / Criteria	g1	g2	g3	g4	g5	g6	g7	g8	g9	g10
Singapore (SGP)	98.2	87.9	91.8	83.1	75.0	86.0	91.6	89.6	84.5	74.3
Denmark (DNK)	92.7	87.9	90.2	89.9	70.0	72.0	91.1	100.0	73.9	85.1
Korea (KOR)	93.4	84.4	99.9	76.3	65.0	74.0	87.4	92.5	84.1	82.9
Hong Kong (HKG)	98.2	93.5	99.3	73.6	75.0	84.0	99.7	95.0	69.1	65.7
New Zealand (NZL)	100.0	86.5	84.0	94.6	100.0	86.0	91.0	84.6	71.5	69.5

Regarding the best-evaluated criteria for each of the nations presented in the ranking of Table 3, The first five economies positioned in this ranking are those with the best performance in the different criteria considered in the evaluation of nations (see Table 4).

The criteria performances of Singapore are one of the highest, the criteria Protecting minority investors (g6) and Enforcing contracts (g9) are the best values. It is the second best evaluated in the Starting a business (g1) criteria, Dealing with construction permits (g2), Getting credit (g5), and Paying taxes (g7). The Doing Business index ranks better New Zealand than Singapore. However, ELECTRE-III ranks better (first position of that ranking) Singapore than New Zealand (Fifth position) (see Table 3).

Continue with the five economy in ranking, Denmark ranks best in Trading across borders (g8) and Resolving insolvency (g10). Korea is the best evaluated for Getting electricity (g3) criteria. For its part, Hong Kong is best evaluated in the criteria of Dealing with construction permits (g2) and Paying taxes (g7). And, New Zealand performed better in the Starting a business (g1), Registering property (g4), Getting credit (g5), and Protecting minority investors (g6) criteria.

4.2. Second instance: different importance weights

In the second instance, a different point of view is considered regarding the relative importance of criteria. It is worthwhile it when a decision-maker is concerned with one or more criteria in the business investment. E. g. For the decision-maker, when cross-border trade (g8) is the most important criterion for making a decision, and the nations best evaluated in this criterion are not found in the top positions, their preferences are not considered in this decision model.

In this sense, considering the decision-maker's preferences, the second instance generates a ranking with different value weights of criteria. In this process, an expert participates in the definition of parameters. Table 5 list the parameters used in ELECTRE-III for the second instance. The most important criteria are Starting a business (g1), Dealing with construction permits (g2), and Getting electricity (g3). The weight value of each criterion g_i is set differently for the first three criteria. The rest is set to 0.07. The indifference (q) and preference (p) threshold is set at 5 and 10, respectively.

Table 5. ELECTRE-III parameters regarding different importance of criteria

Parameters	g1	g2	g3	g4	g5	g6	g7	g8	g9	g10
w	0.2	0.16	0.15	0.07	0.07	0.07	0.07	0.07	0.07	0.07
q	5	5	5	5	5	5	5	5	5	5
p	10	10	10	10	10	10	10	10	10	10

By defining different weights to specific criteria, this second result's ranking differs from the one previously presented in Table 3 and also differs from that presented in Doing Business 2020, with the same weighting for each of the ten criteria. The current ranking from Table 6 shows three new nations that did not appear in those first ten positions from the previous ranking: Lithuania, Taiwan, United Arab Emirates. When analyzing the first five positions of the new ranking, it is found that the first four positions remain the same countries in both rankings generated in this research with ELECTRE-III and in the one presented by the Doing Business.

Table 6. Ten first position of the ranking regarding different importance of criteria

Rank	Code	Economy
1	HKG	Hong Kong
2	SGP	Singapore
3	DNK	Denmark
4	KOR	Korea
5	GBR	United Kingdom
6	NZL	New Zealand
7	LTU	Lithuania
8	TWN	Taiwan
9	GEO	Georgia
10	ARE	United Arab Emirates

The performance of the first five places in the ranking makes it possible to observe that by giving greater weight to the g1, g2 and g3, the order of the nations is influenced by them (see Table 7). Hong Kong now appears in the first place, being the best evaluated in the Starting a business (g1) criterion, like Singapore, which is in the second position of the ranking, indicating that the g1 criterion is the one with the greatest weight according to the parameters defined.

Table 7. Performance of the five first economies regarding the different importance of criteria

Economy / Criteria	g1	g2	g3	g4	g5	g6	g7	g8	g9	g10
Hong Kong (HKG)	98.2	93.5	99.3	73.6	75.0	84.0	99.7	95.0	69.1	65.7
Singapore (SGP)	98.2	87.9	91.8	83.1	75.0	86.0	91.6	89.6	84.5	74.3
Denmark (DNK)	92.7	87.9	90.2	89.9	70.0	72.0	91.1	100.0	73.9	85.1
Korea (KOR)	93.4	84.4	99.9	76.3	65.0	74.0	87.4	92.5	84.1	82.9
United Kingdom (GBR)	94.6	80.3	96.9	75.7	75.0	84.0	86.2	93.8	68.7	80.3

As presented in Table 7, Hong Kong, in addition to being best evaluated in Starting a business (g1), is also the one with the highest score in the Dealing with construction permits (g2) and the second best evaluated in Getting electricity (g3); as well as in Getting credit (g5) and Paying taxes (g7) has the highest score.

In the case of the United Kingdom, which appears in fifth place, it is well evaluated in the Getting credit (g5). Its position is also determined by its performance in the g1, g2, and g3 criteria, which despite not having the best values, is the second or third in their performance.

It should be noted that even though each nation's performance was not modified, by applying a method that considers the preferences of the decision-maker through weight parameters of the criteria or the thresholds of indifference, preference, and veto, the result obtained may vary concerning that published by the World Bank, giving the possibility of choosing the most relevant criteria for a problem.

The decision-maker's preferences in problems of selecting places to do business can also be considered through the weighted sum method, as mentioned by Borissova et al. [6], whose methodology is similar to that used by Doing Business report; the authors assign a non-negative weighted coefficient for relative importance among the five criteria they analyze. However, the ranking with this method is generated by the general average of the performance of the alternatives, and there is no comparison between alternatives.

On the other hand, considering the modifications of the parameters by the decision maker, it can be observed that the implementation of MCDM methods, such as ELECTRE-III, allows a different weighting for each criterion in its weight of importance, as in the indifference thresholds, preference, and veto, allowing the decision maker to obtain the results according to the objectives that are intended to be achieved and selected the most appropriate alternative.

The relevance of using the ELECTRE-III method in problems where nations are compared and an exact evaluation of them is difficult because qualitative aspects are involved. It can be supported by the procedures for exploiting binary overcoming relationships [11], allowing the comparison between nations in an interval allocation format. That is similar to what was presented by Álvarez et al. [4] in its evaluation of the innovation capacity in the regions of Mexico, where the problem is assessed on qualitative scales for specific criteria, heterogeneous scales, and a certain arbitrariness in the construction of the criteria; characteristics that are also present in this investment site evaluation problem and that tend to justify the use of this family of methods in contexts with similar characteristics, where, additionally, the ELECTRE aggregation procedure does not allow compensation between

criteria performance, expressing clearly and simply the evaluation of each alternative in the different criteria, as they are valued [16][4].

As mentioned, multicriteria methods allow criteria to be considered with different weights according to their importance to the decision maker, unlike the report presented by the World Bank Group and the Doing Business 2020 report, where all criteria have the same weight, in the final ranking it is not possible to generate an in-depth analysis of the performance of the alternatives in each criterion. As well as, using a weighted sum method does not allow identifying in which criteria the alternatives differ or are similar to each other, being a relevant aspect when choosing a decision option.

Analyze different alternatives in a decision problem, specifying criteria and their relative importance for each one through weights, parameters of indifference and preference, implementing multicriteria methods for decision-making, such as the one applied in this research work with ELECTRE-III, allows to incorporate different points of view of the decision maker and even in an investment location problem, allows the option of considering ranges between the performances of the alternatives in a holistic way [8] based on their same preferences and objectives.

4.3. Sensitivity Analysis

Following the last action of Step 2 in Figure 1, it corresponds to the sensitivity analysis. The objective of the sensitivity analysis is to examine the robustness of the proposed solution, where the expert provides a range of values to modify in different parameters even considering their preferences [23] [5].

The procedures in this stage were established into scenarios that showed changes in the indifference and preference thresholds and weights values of some of the ten criteria considered for this problem. The expert, supported by the analyst, makes some modifications according to his understanding of the problem and preferences. Table 8 shows the used values on that parameter modification. The changes in the different scenarios were established as follows:

- Scenario 1. Change in a single criterion, g1, in the value of the preference threshold (p).
- Scenario 2. Change in a single criterion, g1, in the value of the indifference threshold (q).
- Scenario 3. Change in two criteria, g2, and g3, in the preference threshold values (p).
- Scenario 4. Change in two criteria, g2, and g3, in the values of the indifference threshold (q).
- Scenario 5. Change in two criteria, g2, and g3, in the weight values of the criteria (w).

In the sensitivity analysis process, five scenarios are made according to the variations of values of parameters (see Table 8). The ELECTRE-III method was applied in each scenario resulting in five rankings shown in Table 9.

The rankings of scenarios 1 and 2 are the same as the proposed ranking of the Table 3. On the other hand, in the remaining scenarios, there were minimal variations concerning the position of the nations, which are marked in gray. These variations consist mainly of a change in the position of the nations, such is the case of Scenarios 3, 4, and 5. For example, in Scenario 3, Georgia appears in eighth position and Taiwan in ninth, however,

Table 8. Parameters in sensitivity analysis scenarios

Scenario	Criteria change	Parameters		
		w	q	p
1	g1	0.2	5	20
2	g1	0.2	10	10
3	g2	0.16	5	13
	g3	0.15	5	14
4	g2	0.16	8	10
	g3	0.15	3	10
5	g2	0.18	5	10
	g3	0.13	5	10

Table 9. Ranking in sensitivity analysis scenarios

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 4
Rank	Economy	Economy	Economy	Economy	Economy
1	Hong Kong	Hong Kong	Hong Kong	Hong Kong	Hong Kong
2	Singapore	Singapore	Singapore	Singapore	Singapore
3	Denmark	Denmark	Denmark	Korea	Denmark
4	Korea	Korea	Korea	Denmark	Korea
5	United Kingdom	United Kingdom	United Kingdom	United Kingdom	New Zealand
6	New Zealand	New Zealand	New Zealand	New Zealand	United Kingdom
7	Lithuania	Lithuania	Lithuania	Taiwan	Taiwan
8	Taiwan	Taiwan	Georgia	Lithuania	Lithuania
9	Georgia	Georgia	Taiwan	United Arab Emirates	Georgia
10	United Arab Emirates	United Arab Emirates	Sweden	Georgia	Norway

in the ranking accepted by the expert (Table 3), these two nations are in reverse order, that is, Taiwan in eighth position and Georgia in ninth position. In the same way, in Scenarios 4 and 5, the nations shaded in gray present variation in position to the final ranking, as they are positioned in an inverted manner.

The nations shaded in green in Scenarios 3 and 4, Sweden and Norway, respectively, did not appear in the first ten positions in the proposal accepted by the expert; however, in that ranking, both nations were in the eleven and twelve positions and did not present significant variation concerning the preferences of the decision maker. This analysis concludes the sensitivity analysis process, showing stability in the ranking provided as the final to the expert.

4.4. Method Comparison: ELECTRE-III and PROMETHEE

In this section, a comparison between the outranking ELECTRE-III and PROMETHEE methods is performed. It aims to compare the rankings, highlighting coincidences and differences in the nations' orders.

PROMETHEE is an outranking method working with a finite set of alternatives based on often conflicting criteria [9]. It is based on six forms of preference functions (see [7]). Each criterion can apply any preference function.

- Usual Criterion
- U-shape Criterion (or quasi criterion)
- V-shape Criterion (or criterion with linear preference)
- Level criterion
- V-shape with indifference Criterion (or criterion with linear preference and indifference area)
- Gaussian Criterion

It seems the functions of preference V-Shape and V-Shape with an indifference criterion are most used [24]. In comparing methods, the selected preference function for PROMETHEE is V-Shape with an indifference criterion. The selected preference function in PROMETHEE is the same function ELECTRE-III uses to construct the fuzzy outranking relation between alternatives $\sigma(a_i, a_l)$. In the current preference function, the indifference (q) and preference (p) threshold are defined. The alternatives a_i and a_l are considered indifferent until the difference between them does not exceed q. Above this threshold, the degree of preference (p) increases linearly until a strict preference is reached [7].

In order to carry out the comparison of the results of ELECTRE-III and PROMETHEE, the same definition of indifference and preference thresholds was applied, $q = 5$ and $p = 10$, respectively. The weight considered for the criteria in this analysis considers the expert's preferences, where he considers three criteria particularly important, which can be observed in Table 5. Table 10 shows the ranking of the first ten positions of the nations according to the application of PROMETHEE and ELECTRE-III, respectively.

The resulting rankings from applying the PROMETHEE and ELECTRE-III methods (Table 10) show some differences in the position of nations. It is possible to observe that the ten nations continue in the first ten positions, with some position variations; Hong

Table 10. Ten first position of the PROMETHEE and ELECTRE-III rankings

	PROMETHEE	ELECTRE-III
Rank	Economy	Economy
1	Hong Kong	Hong Kong
2	Singapore	Singapore
3	New Zealand	Denmark
4	Denmark	Korea
5	Georgia	United Kingdom
6	Korea	New Zealand
7	United Kingdom	Lithuania
8	United Arab Emirates	Taiwan
9	Taiwan	Georgia
10	Lithuania	United Arab Emirates

Kong and Singapore persist in the same position (first and second, respectively) in both rankings.

The differences in the rankings lie from the third position, having that with the ranking obtained with PROMETHEE, New Zealand is positioned in the third place; on the other hand, this same nation, in the ranking with ELECTRE-III, is in the sixth position. Similarly, Georgia is the nation that occupies the fifth position in the ranking generated by PROMETHEE, and the ninth in the one generated by ELECTRE-III, with significant differences to be considered in the rankings.

An interesting aspect of the variation in the rankings is that ELECTRE placed Lithuania in seventh position, better than Taiwan and the United Arab Emirates. However, PROMETHEE places Lithuania in the tenth position. On the other hand, Korea and the United Kingdom present the same order between them in both rankings; however, PROMETHEE considers these nations in positions 6^{th} and 7^{th}, and ELECTRE-III places them in positions 4^{th} and 5^{th}, respectively.

With the above, despite applying the two methods considering the same weight parameters and indifference and preference thresholds, the compared methods differ mainly in the exploitation process of the valued matrix. When analyzing in detail the performance of the alternatives and their ordering, it is possible to observe that in the ranking generated by PROMETHEE, of the five best-positioned alternatives, two have the lowest performance in two of the three criteria considered most important by the expert. On the other hand, of the first five alternatives in the ranking obtained by ELECTRE-III, they generally have a better evaluation in the three criteria with the most significant weight for the decision-maker.

Analyzing the results obtained by both mentioned methods allows both the analyst and the decision maker to consider applying one method or another to the problem posed in this investigation, selecting the ELECTRE-III method as the one that provides the ranking that most reflects the user's preferences decision maker. One of the detected strengths of this method is that it allows a more intuitive differentiation for the decision maker in comparing pairs of alternatives, even when they have very similar performances in specific evaluation criteria; this is supported by the ELECTRE-III procedure by classifying nations

according to their concordance index and credibility matrix, thus evaluating the strength of the statement "a_i is at least as good as a_l".

In the current application, the ELECTRE-III is desirable when the DM is willing and knows the values of the indifference and preference situation when comparing alternatives by each criterion. It means she/he is able to define if "$g_j(a_i)$ is at least as good as $g_j(a_l)$". When the difference between alternatives is not in the indifference or preferences situation, then the fuzzy number represents the uncertainty. On the other hand, the ELECTRE-III is inadequate if the DM and analyst are unwilling to express the uncertainty with indifference and preference situation.

The binary outranking relations expressed in ELECTRE enables the formulation of recommendations in an interval format [12]. It supports the comparison of nations, particularly when it is difficult to derive exact investment assessments. The method represents the imperfect knowledge that characterizes the decision model.

The multicriteria aggregation procedure of ELECTRE is conceived such that they do not allow for compensation of performances among criteria [17]. The Countries' business attraction can be analyzed with the ELECTRE-III, in case the expert explicitly considers cases where business attraction deteriorates significantly due to poor performance on specific critical criteria.

The use of ELECTRE methods is particularly pertinent in contexts where at least one of the following features is present [17]: 1) the presence of qualitative scales for some criteria; 2) the presence of heterogeneous scales; 3) the need for avoiding systematic compensatory effects; 4) the need to take into account the imperfect knowledge of data and some arbitrariness when building criteria; and 5) the need of taking into account the reasons for and the reasons against an outranking. In the current problem, at least the features 3) and 4) are presented.

5. Conclusions

The problem of choosing an investment site is relevant for those investors who seek to select the ideal location to set up a company. In the same way, this is a relevant problem for the governmental leaders of the nations intending to be a competitive market and attract investors.

In that sense, in this paper, we have presented a ranking of nations according to their ease of doing business, applying the MCDM ELECTRE-III method, defining criteria weight parameters, indifference, and preference thresholds. This research evaluated various aspects of several nations, such as Dealing with construction permits, Registering property, and trading across borders, among others. That criteria are valuable information according to international organizations that impartially evaluate these aspects, serving as a reference for various studies.

Identifying investment locations can be challenging for business leaders and governments looking to expand their international presence, putting financial capital and global market position at risk. Thanks to the opening of markets, the need to be at the forefront of economic changes, and the accessibility of information through digital media, it is possible to have data that allows an evaluation of different locations for the installation of a company, this being an advantage to carry out a decision.

A large number of criteria are involved in the problems of choosing locations to invest; in this sense, presenting rankings obtained with a multicriteria decision-making method for investment location selection problems provides the opportunity to consider information published by international organisms, such as the World Bank Group by Doing Business study and report, with the possibility of adding other criteria that may also be of interest to decision-makers.

The multicriteria decision-making methods allow differentiating the weights of the criteria according to the objectives to be achieved and the decision-maker's preferences based on an investment decision and having that the application of ELECTRE-III for investment site selection problems, as well as similar problems, results in a ranking of the nations according to the assessment of each evaluated criterion corresponding to the weight assigned to each of them, thus causing obtaining information that allows decision-making that reflects the decision-maker's preferences and analyzes all the aspects defined as relevant for an optimal decision.

References

1. Álvarez, P., Muñoz-Palma, M., Miranda-Espinoza, L.E., Lopez-Parra, P., León-Castro, E.: Multiple criteria hierarchy approach for analyzing competitiveness of states in mexico. Inquietud Empresarial 20(2), 29–51 (2020)
2. Alvarez, P.A., Ishizaka, A., Martínez, L.: Multiple-criteria decision-making sorting methods: A survey. Expert Systems with Applications 183, 115368 (2021)
3. Alvarez, P.A., Morais, D.C., Leyva López, J.C., de Almeida, A.T.: An ELECTRE III based consensus-reaching process to improve a collective solution. International Transactions in Operational Research 29(2), 1048–1088 (2022)
4. Alvarez, P.A., Valdez, C., Dutta, B.: Analysis of the innovation capacity of mexican regions with the multiple criteria hierarchy process. Socio-Economic Planning Sciences 84, 101418 (2022)
5. Alvarez Carrillo, P.A., León Santiesteban, M., Gastelum Chavira, D.A., Vega Osuna, L.A.: An empirical analysis of competitiveness on cities of sinaloa, mexico with an outranking method. In: Fourth International Workshop on Knowledge Discovery, Knowledge Management and Decision Support. pp. 156–163. Atlantis Press (2013)
6. Borissova, D., Korsemov, D., Mustakerov, I.: Multi-criteria decision making problem for doing business: Comparison between approaches of individual and group decision making. In: Computer Information Systems and Industrial Management. pp. 385–396. Springer International Publishing, Cham (2019)
7. Brans, J.P., Vincke, P., Mareschal, B.: How to select and how to rank projects: The promethee method. European journal of operational research 24(2), 228–238 (1986)
8. Chejarla, K.C., Vaidya, O.S.: Ease of doing business: Performance comparison of g20 countries using gray mcdm. International Journal of Information Technology & Decision Making pp. 1–41 (2022)
9. De Lima Silva, D.F., Silva, J.C.S., Silva, L.G., Ferreira, L., De Almeida-Filho, A.T.: Sovereign credit risk assessment with multiple criteria using an outranking method. Mathematical Problems in Engineering 2018, 1–11 (2018)
10. Dias, J., Figueira, J.R., Roy, B.: The software ELECTRE III-IV: methodology and user manual (Version 3.X). Université Paris-Dauphine LAMSADE, Paris (2006)
11. Doumpos, M., Figueira, J.R.: A multicriteria outranking approach for modeling corporate credit ratings: An application of the electre tri-nc method. Omega 82, 166–180 (2019)

12. Doumpos, M., Figueira, J.R.: A multicriteria outranking approach for modeling corporate credit ratings: An application of the electre tri-nc method. Omega 82, 166–180 (2019)
13. Ekel, P., Bernardes, P., Vale, G.M.V., Libório, M.P.: South american business environment cost index: reforms for brazil. International Journal of Business Environment 13(2), 212–233 (2022)
14. Estevão, J., Lopes, J.D., Penela, D., Soares, J.M.: The doing business ranking and the GDP. a qualitative study. Journal of Business Research 115, 435–442 (2020)
15. Figueira, J., Roy, B.: Determining the weights of criteria in the ELECTRE type methods with a revised simos' procedure. European Journal of Operational Research 139(2), 317–326 (2002)
16. Figueira, J.R., Greco, S., Roy, B., Słowiński, R.: An overview of electre methods and their recent extensions. Journal of Multi-Criteria Decision Analysis 20(1-2), 61–85 (2013)
17. Figueira, J.R., Greco, S., Roy, B., Slowinski, R.: An overview of electre methods and their recent extensions. Journal of Multi-Criteria Decision Analysis 20(1-2), 61–85 (2013)
18. Garcia-Gastelum, T.S., Uzeta-Obregon, C.R., Alvarez, P.A., Espinoza-Audelo, L.F., León-Castro, E.: Building a regional employability indicator based on ordered weighted average operators. Cybernetics and Systems 53(7), 1–23 (2022)
19. Group, W.B.: Doing business: midiendo regulaciones para hacer negocios. World Bank (2020), [Online]. Available: https://espanol.doingbusiness.org/es/doingbusiness
20. Group, W.B.: Datos de libre acceso del banco mundial. World Bank (2021), [Online]. Available: https://datos.bancomundial.org/
21. Gryshova, I., I., K., Mitiai, O.: Ukraine's positions in international ratings evaluation as a factor of its competitiveness. Economic Annals-XXI 151(5–6), 24–27 (2015)
22. López, J.C.L., Carrillo, P.A.Á., Valenzuela, O.A.: A multicriteria group decision model for ranking technology packages in agriculture. In: Soft computing for sustainability science, pp. 137–161. Springer (2018)
23. Malczewski, J.: Multiple criteria decision analysis and geographic information systems. Trends in multiple criteria decision analysis pp. 369–395 (2010)
24. Martínez López, L., Ishizaka, A., Qin, J., Álvarez Carrillo, P.A.: Multi-Criteria Decision-Making Sorting Methods: Applications to Real-World Problems. Academic Press, London (2023)
25. Muñoz-Palma, M., Alvarez-Carrillo, P.A., Miranda-Espinoza, E.L., Avilés-Ochoa, E., León-Castro, E.: Multicriteria analysis model for the evaluation of the competitiveness of the states in mexico. In: Intelligent and Complex Systems in Economics and Business, pp. 1–20. Springer (2021)
26. Pinheiro-Alves, R., Zambujal-Oliveira, J.: The ease of doing business index as a tool for investment location decisions. Economics Letters 117(1), 66–70 (2012)
27. Roy, B.: The outranking approach and the foundations of ELECTRE methods. In: Bana e Costa, C. (ed.) Reading in Multiple Criteria Decision Aid, pp. 155–183. Springer-Verlag, Berlin (1990)
28. Ruiz, F., Cabello, J.M., Pérez-Gladish, B.: Building ease-of-doing-business synthetic indicators using a double reference point approach. Technological Forecasting and Social Change 131, 130–140 (2018)
29. Soares Silva, J.C., de Lima Silva, D.F., Ferrerira, L. de Almeida-Filho, A.T.: A dominance-based rough set approach applied to evaluate the credit risk of sovereign bonds. 4OR 20(1), 139–164 (2022)

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