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A Classification Of Brazilian States Based On HDI Data Using The Vikor Multicriteria Technique: Preliminary Results.

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Abstract
The Multi-Criteria Analysis Is Used For Decision-Making With Conflicting Criteria Or Not, Offering The Manager An Instrument For His Evaluation. Based On These Criteria, It Is Possible To Rank The Best Or Worst Options With Available Criteria. The HDI Aims To Determine The Degree Of Development Of An Economy Based On Three Indicators: Income, Education And Life Expectancy. In This Article, The Same Criteria Used By The HDI Are Used To Identify Whether There Are Discrepancies Between The Best And Worst Federation Units In The Year 2021, Based On The Use Of The VIKOR Criterion Compared With The HDI.
Key Word*: Human Development Index; Multicriteria Techniques; VIKOR*

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I. Introduction

The Human Development Index - HDI is an indicator created by the United Nations to determine the degree of development of a society. Its structure is formed by three criteria with equal weights: income, schooling, and life expectancy. Where each of the data presented, are standardized. Thus, information with the highest value will be equal to 1 and the lowest value equal to zero. With the average of the three criteria, a table is presented, whose values close to one are considered ideal, while values close to zero are not considered ideal.

Over the past twenty years, Brazilian human development indicators have shown continuous improvement. According to the Human Development Report 2021/2022: Uncertain Times, Unsettled Lives: Shaping our Future in a Transforming World, Brazil's HDI in 2021 was 0.754, occupying the 87th position in the ranking among 191 countries. In 2020, it was ranked 86th, with an index of 0.758. These results place Brazil at th

Table 1:

Table 1: Classification of degree of development based on Human development Index.

Degree of development	**Human Development Index**
Very Low	0,000 – 0,499
Low	0,500 – 0,599
Medium	0,600 – 0,699
High	0,700 – 0,799
Very high	0,800 – 1,000

Fonte: PNUD/Atlas do Desenvolvimento Humano no Brasil

Although the Brazilian economy is at a level close to very highly developed economies, the regional reality presents great discrepancies. Historically, regional differences are striking, where part of Brazil has a more modern economy linked to export activities and better qualified labor, while another part depends on public sector resources and State support in support programs social.

Based on the information provided by IPEADATA, the HDI data in 2021 for the Brazilian states showed a ranking of the best and worst. This year the five best states to live in were: Federal District, São Paulo, Santa Catarina, Minas Gerais and Espírito Santo. While the states considered the worst in this classification were: Pará, Piauí, Amapá, Alagoas and Maranhão.

This research aims to investigate whether this classification could undergo substantial changes with the introduction of multicriteria techniques, in particular the use of the VIKOR technique. It is clear in this research

that it is not its objective to change the perception of development of a region, but only to investigate whether the ranking between the worst and the best Federation Units presents large discrepancies with this criterion.

II. Methodology

Multi-criteria decision-making is essentially used at a managerial level, in choosing the best alternatives based on different criteria. Its use takes place in the most diverse fields of economic activity. Multicriteria methods seek to classify available alternatives according to established criteria. There are several multicriteria methods available in the literature, such as: TOPSIS, AHP, MACBETH, ELECTRE, PROMETHEE, and VIKOR.

The VIKOR criterion, presented by Opricovic (1998) based its idea on Compromise Programming problems by Yu (1973) and Zeleny (1982).The initial idea of the model is to establish a ranking according to the distances in relation to an ideal scenario. The VIKOR method (Vlse Kriterijumska Optimizacija Kompromisno Resenje) which means multicriteria optimization and compromise solution in Serbian) has already become a very popular multicriteria decision making tool due to its computational simplicity and solution accuracy. This process focuses on selecting and ranking a set of viable alternatives and determining a compromise solution to a problem with conflicting criteria to help the decision maker reach a final course of action.

Basically, the solution norm is introduced as a linear combination of the Manhattan distance and Chebychev distance metrics. Where the first represents the "maximum utility of the group" (priority rule) and the second represents the minimum individual weight of the opponent (TZIMOPOULOS et al; 2013). As a result, this technique determines the ranking list of compromises based on the measure of proximity to the optimal solution.

The commitment ranking produced by VIKOR basically has five stages (PAPATHANASIOU et al, 2018):

Step 1: determine the best f_{ij}^{*} $(best\ value\ or\ measure\ of\ utility)$ and f_j^{-} $(worst\ value\ or\ measure\ of\ regret)$ for all values and criteria.

For when the role is to maximize benefitsf_{ij}^{*} $(best\ value)$, we have:

$f_j^{*} = \max_i f_{ij}$, $f_j^{-} \min_i f_{ij}$. Onde i = 1,2, ... n (criteria) e j =1,2,.... n (alternatives)

For when the role is to minimize costsf_j^{-} $(worst\ value)$, we have:

$f_j^{*} \min_i f_{ij}$, $f_j^{-} = \max_i f_{ij}$ Onde i = 1,2, ... n (criteria) e j =1,2,.... n (alternatives)

From a decision matrix and weight vector, identify the values f_{ij}^{*} $(best\ value\ )$ and f_j^{-} $(pworst\ value)$

It should be noted that the value that represents the best result obtained by the variable is considered maximum, and there may be variables described as "the higher the better" and variables described as "the smaller the better". Analogous interpretation is possible for the worst-case scenario.

Step 2: Calculate the values forS_i and R_i ,

S_i = Utility Measure

R_i = Measure of Repentance

To calculateS_i e R_i the following formulas are required:

$S_i = \sum_i^n w_j \frac{(f_j^{*} - f_{ij})}{(f_j^{*} - f_j^{-})}$, i = 1,2, ... , m j= 1,2, ..., n.

$R_i = \max_j [\left(w_j \frac{(f_j^{*} - f_{ij})}{(f_j^{*} - f_j^{-})} \right]$, i = 1,2, ... , m j= 1,2, ..., n.

Step 3: Calculate the Qi values, given i=1, 2,..., n. Considering for this the equation:

$Q_i = v(\frac{(S_i - S^{*})}{(S^{-} - S^{*})} + (1 - v)(\frac{(R_i - R^{*})}{(R^{-} - R^{*})}$, i = 1,2,3, ...m

Where $S^{*} = \min i\, S_i$; $S^{-} = \max i\, S_i$; $R^{*} = \min R\, S_i$; $R^{-} = \max i\, R_i$; v is introduced as a weight for the best strategy or maximum utility of the group.

Initially the compromise strategy can be $v = 0{,}5$.

S* = max Si; S- = min S_i like this R* = max R_i ; R− = min R_i The weight v is a weighting described by the authors as a major criterion. It is customary to define it as v = 0,5, however, this criterion may change due to the hypothesis of robustness of the classification.

Step 4: Rank the alternatives.

When ranking the alternatives, the values for S_i, R_i and Q_i must be placed in ascending order.

Step 5: Propose a compromise, based on two conditions:

First Condition – C1 - The difference between the best alternative (A1) and the second-best alternative (A2) must be greater than or equal to the DQ.

Condition 1: a' has an «Acceptable Advantage» over the others if, when compared with a" (immediately subsequent alternative), it is verified that:

$$Q(A^2) - Q(A^1) \geq DQ$$

Where:

$Q(A^2)$ *is the second best ranked* e $Q(A^1)$ *is the first best ranked*

$DQ = \frac{1}{m-1}$

Second Condition – C2 - The alternative$Q(A^1)$ should be better ranked in S_i and/or R_i

Caso $Q(A^2) - Q(A^1) < DQ$ the difference between the best ranked in relation to the second is less than DQ, then the difference between the first and the third best alternative is considered:

$$Q(A^3) - Q(A^1) \geq DQ$$

III. Results analysis

In 2021, the Human Development Index of the Federation Units showed very clearly the x-ray of the quality of life of the Brazilian states. Table 1 shows the difference between the best and worst states. Such results are not recent, since the second half of the 20th century, differences in quality of life have resulted in the existence of two Brazils, one considered rich and the other considered poor (BACHA, 2015) When analyzing the state indicators presented the term "belindia" to characterize this situation.

In the last ten years, the Brazilian economy has shown a reduced pace of economic growth, the result of an economic model based on increasing the supply of credit and the population's indebtedness, without increasing productivity. During this period, the negative effects of covid_19 on productive activity should also be considered.

Table 1: Brazil - Human Development Index of the Federation Units in 2021

Federation Unit	HDI	Longevity	Income	Education
Acre	0,710	0,788	0,655	0,692
Alagoas	0,684	0,748	0,630	0,679
Amazonas	0,700	0,744	0,641	0,720
Amapá	0,688	0,778	0,648	0,647
Bahia	0,691	0,772	0,648	0,659
Ceará	0,734	0,784	0,658	0,766
Distrito Federal	0,814	0,803	0,821	0,817
Espírito Santo	0,771	0,864	0,715	0,742
Goiás	0,737	0,721	0,714	0,778
Maranhão	0,676	0,715	0,603	0,716
Minas Gerais	0,774	0,846	0,718	0,762
Mato Grosso do Sul	0,742	0,751	0,733	0,741
Mato Grosso	0,736	0,730	0,720	0,758
Pará	0,690	0,744	0,645	0,686
Paraíba	0,698	0,779	0,653	0,669
Pernambuco	0,719	0,797	0,647	0,721
Piauí	0,690	0,726	0,649	0,698
Paraná	0,769	0,785	0,744	0,780
Rio de Janeiro	0,762	0,769	0,759	0,758
Rio Grande do Norte	0,728	0,819	0,692	0,680
Rondônia	0,700	0,731	0,677	0,694
Roraima	0,699	0,745	0,680	0,673
Rio Grande do Sul	0,771	0,797	0,767	0,750
Santa Catarina	0,792	0,827	0,759	0,790
Sergipe	0,702	0,764	0,662	0,684
São Paulo	0,806	0,810	0,771	0,839
Tocantins	0,731	0,779	0,684	0,732

Source: IPEADATA

In the construction of the measure of utility $\boldsymbol{S_i}$ and the measure of regret $\boldsymbol{R_i}$ the same weights used in the construction of the HDI were used. Thus, each of the criteria has the same participation (one third of the total).

Table 2: SI and RI calculation for each Federation Unit in 2021

Federation Unit	$\boldsymbol{S_i}$	$\boldsymbol{R_i}$
Acre	0,6791	0,2552
Alagoas	0,8293	0,2920
Amazonas	0,7503	0,2752
Amapá	0,7903	0,3333
Bahia	0,1772	0,0715
Ceará	0,1260	0,0662
Distrito Federal	0,0323	0,0235
Espírito Santo	0,0816	0,0430
Goiás	0,1228	0,0552
Maranhão	0,1949	0,0885
Minas Gerais	0,0794	0,0418
Mato Grosso do Sul	0,1183	0,0436
Mato Grosso	0,1249	0,0517

Pará	0,1785	0,0715
Paraíba	0,1685	0,0682
Pernambuco	0,1434	0,0706
Piauí	0,1791	0,0698
Paraná	0,0852	0,0313
Rio de Janeiro	0,0940	0,0367
Rio Grande do Norte	0,1329	0,0632
Rondônia	0,1674	0,0585
Roraima	0,1691	0,0660
Rio Grande do Sul	0,0831	0,0354
Santa Catarina	0,0589	0,0252
Sergipe	0,1647	0,0646
São Paulo	0,0411	0,0208
Tocantins	0,1309	0,0556
S* R*	0,0323	0,0208
S-, R-	0,8293	0,3333
S- - S*	0,7971	0,3125

Source: IPEADATA and tabulation by the author

The sensitivity analysis aims to assess the robustness of the trade-off identified by the original decision model. In the analysis carried out here, a change was imposed on the parameter v , that is, a change in the balance between the global and individual performance of each of the alternatives, to verify the impact on the ranking Q . The solution of the decision model is evaluated for different values of v assumed on the interval [0, 1].

In table 3, we have the results of the compromise solution, when v = 0.50. The data show that the five best units of the federation were: Distrito Federal, São Paulo, Santa Catarina, Paraná and Rio Grande do Sul. Already, the worst evaluated federation units in: Maranhão, Acre, Amazonas, Alagoas and Amapá.

Table 3: Classification based on VIKOR criteria.

Estado	**V = 0,5**
Distrito Federal	0,00432
São Paulo	0,00556
Santa Catarina	0,02365
Paraná	0,04988
Rio Grande do Sul	0,05515
Minas Gerais	0,06311
Rio de Janeiro	0,06403
Espírito Santo	0,06645
Mato Grosso do Sul	0,09036
Goiás	0,11176
Tocantins	0,11755
Rio Grande do Norte	0,13087
Ceará	0,13138
Rondônia	0,14497
Pernambuco	0,14939
Sergipe	0,15304
Mato Grosso	0,15686
Roraima	0,15803
Paraíba	0,16128
Piauí	0,17050
Bahia	0,17203
Pará	0,17275
Maranhão	0,21027
Acre	0,78073
Amazonas	0,85744
Alagoas	0,93394
Amapá	0,97548

Source: IPEADATA and tabulation by the author

In the following table, we have the classification of the Federation Units in relation to the HDI and with the compromise solution, between different situations: when v = 0.25; 050; and 0.75. Although the order of the five best and the five worst units of the Federation present small differences, when the value of v. They are not enough to change this table, of the top five and the bottom five, based on the VIKOR criteria. However, when comparing this ranking with the HDI, it is already possible to notice differences, for example: Minas Gerais and Espírito Santo are in the top five. On the other hand, the Federal District, São Paulo and Santa Catarina represent the three best options regardless of the criterion and value of v.

A similar scenario is also found for the selection of the worst Federation Units, in this table Amapá and Alagoas compete for the worst position, in the classification based on the VIKOR criterion. However, when comparing the results of the HDI, the state of Maranhão is the worst classified, followed by Alagoas and Amapá.

Table 4: Comparison of ranking by traditional with chosen VIKOR.

Classificação	**HDI**	***v= 0,50***	***v = 0,25***	***v = 0,75***
1	Distrito Federal	Distrito Federal	São Paulo	Distrito Federal
2	São Paulo	São Paulo	Distrito Federal	São Paulo
3	Santa Catarina	Santa Catarina	Santa Catarina	Santa Catarina
4	Minas Gerais	Paraná	Paraná	Paraná
5	Espírito Santo	Rio Grande do Sul	Rio Grande do Sul	Rio Grande do Sul
6	Rio Grande do Sul	Minas Gerais	Rio de Janeiro	Minas Gerais
7	Paraná	Rio de Janeiro	Minas Gerais	Espírito Santo
8	Rio de Janeiro	Espírito Santo	Espírito Santo	Rio de Janeiro
9	Mato Grosso do Sul	Mato Grosso do Sul	Mato Grosso do Sul	Mato Grosso do Sul
10	Goiás	Goiás	Goiás	Goiás
11	Mato Grosso	Tocantins	Tocantins	Tocantins
12	Ceará	Rio Grande do Norte	Mato Grosso	Ceará
13	Tocantins	Ceará	Rondônia	Rio Grande do Norte
14	Rio Grande do Norte	Rondônia	Rio Grande do Norte	Pernambuco
15	Pernambuco	Pernambuco	Ceará	Rondônia
16	Acre	Sergipe	Sergipe	Sergipe
17	Sergipe	Mato Grosso	Roraima	Roraima
18	Amazonas	Roraima	Pernambuco	Paraíba
19	Rondônia	Paraíba	Paraíba	Bahia
20	Roraima	Piauí	Piauí	Piauí
21	Paraíba	Bahia	Bahia	Pará
22	Bahia	Pará	Pará	Mato Grosso
23	Pará	Maranhão	Maranhão	Maranhão
24	Piauí	Acre	Acre	Acre
25	Amapá	Amazonas	Amazonas	Amazonas
26	Alagoas	Alagoas	Alagoas	Amapá
27	Maranhão	Amapá	Amapá	Alagoas

Source: IPEADATA and tabulation by the author

IV. Conclusions

The adoption of a differentiated methodology in the calculation of the HDI did not cause significant alterations, regarding the results presented, with the degree of development of the Federative Units considered poorer and those considered richer. Although, in this article, the results of the sensitivity tests are not considered, since the objective was to verify a discrepancy between the data provided by the HDI and those provided using the VIKOR Technique, the results found point to a convergence between the group of the most developed and the less developed group, regardless of the criterion and value of v.

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