EVALUATION OF COMPANIES IN THE MINING AND STEEL INDUSTRY SECTOR USING THE MULTI-CRITERIA DECISION SUPPORT METHOD AHP-TOPSIS-2N

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1. INTRODUCTION

The analysis process in the financial market can be viewed from several perspectives. This paper will use an approach known as fundamental analysis, which makes use of companies' operational data to measure their performance over time.

According to Albadvi *et al.* (2006), Fundamental analysts analyze audit reports, income statements, quarterly balance sheets, dividend records, sales records, management resources, and the company's competitive situation and then calculate the intrinsic value of each share based on the cash flow forecast for the coming years. This approach brings a medium to long-term view since these are analyses of the companies' quarterly balance sheets which show operational evolution over the course of time. Within the fundamental analysis, there is a process of evaluating the best companies to allocate in the portfolio according to their potential performance. It involves a decision-making process for sorting these shares according to an evaluation of the selected criteria.

According to Gomes & Gomes (2019), decisions can be classified in a variety of ways, such as simple or complex; specific or strategic, among others. And the consequences resulting from decisions can be immediate, short-term, long-term, or a combination of the aforementioned types.

In this scenario, arises the opportunity of developing a paper using multi-criteria decision support methods. This study aims to evaluate IBOVESPA companies for allocation in an investment portfolio utilizing the AHP-TOPSIS-2N Method. In the construction of the paper, the main fundamental analysis indicators will be used to sort the companies. The criteria and the method used will be detailed in the next sections.

The paper is structured as follows: Section 2 discusses the Theoretical References regarding decision-making indicators in finances and the AHP-TOPSIS-2N method. Section 3 describes the research methodology. Section 4 describes the research results with the multi-criteria method's application. Lastly, section 5 presents the conclusion of the study.

2. THEORETICAL REFERENCES

2.1. Indicators of Decision Making in Finance

Fundamental analysis indicators are used for a relative evaluation between companies. The goal is to evaluate an asset by comparing its price to the price of similar assets in the market. To make this possible, these prices need to be standardized, turning these values into

multiples of common variables. These multiples are usually standardized in relation to the profits generated by the companies, the book or market value of the company, and the revenues generated.

As in discounted cash flow valuation, the value of the multiples is a function of the company's ability to generate cash flow, the expected growth in those cash flows, and the uncertainty of those cash flows. Changes in the values of these variables change the values of the multiples. The study used as a basis the indicator Price over Earnings (P/E). In this indicator, the share price is divided by the earnings per share, thus analyzing how much the market prices the company in relation to its earnings. The closer to zero, the better the opportunity for investment. The Price over Equity Value (P/EV) was also used, which is the price of a share divided by its asset value. It indicates how much investors are willing to pay for the company's equity. *Dividend Yield* represents how much the company has paid out in dividends in the last 12 months. *Return on Equity* (ROE): Return on Equity is a profitability indicator that serves to determine how efficient a company is at generating profit from its resources. ROE considers the net equity and the amounts invested in the business, including that of shareholders. *Return On Invested Capital* (ROIC): The Return on Invested Capital is also a profitability indicator, but it considers as invested capital the capital of third parties as well as its own capital. The profit considered for this indicator is NOPAT, which is the Operating Profit (EBIT) after taxes.

2.2. AHP-TOPSIS-2N Method

In this paper, we will discuss the AHP-TOPSIS-2N method, which is a hybrid model that makes use of AHP to define the weights of each alternative. The TOPSIS method is used to provide the sorting of the alternatives and, finally, there are two normalizations (2N) to validate the result presented in the methods.

In the construction of this hybrid model, we have the AHP (Analytic Hierarchy Process) method, created by Thomas Saaty in the 1970s. AHP gives the opportunity to understand the indicators and their importance to pairs as criteria. (Souza et al., 2018)

This decision support method has become very popular because of its ease of use. In this hybrid model, AHP is used with the purpose of pondering the weights of the criteria according to the Saaty Fundamental Scale, as can be seen in table 1:

Table 1: Saaty Fundamental Scale

Intensity	Definition	Explanation
1	Equal Importance	Both activities equally contribute to the objective.
3	Minor importance of one over the other.	Experience and judgment favor one activity over another.
5	High or essential importance	Experience and judgment strongly favor one activity over the other.
7	Major importance or demonstrated importance	One activity is heavily favored over the other. Can be demonstrated in practice.
9	Absolute Importance	The evidence favors one activity over another with the highest degree of certainty.
2, 4, 6, 8	Intermediate values	When you are looking for a compromise condition between two definitions.

Source: SAATY (1980)

This method defines the weights of each criterion in the evaluation of the alternatives in order to evaluate consistency. AHP calculates the Consistency Ratios (CR) between the Consistency Index (CI) of the judgments and the Random Consistency Index (RI). For the validation of an acceptable level of reliability, the Consistency Ratio should be below 10% (Table 2).

Table 2: IR values for use in calculating the Consistency Ratio

N	2	3	4	5	6	7	8	9
RI	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Source: SAATY (1980)

The TOPSIS method was created by Hwang and Yoon (1981). Its acronym stands for Technique for Order Preferences by Similarity to Ideal Solution.

This method stands out for its intuitive use and unlimited number of alternatives, unlike many other methods that use comparative approaches. The best alternative is the one that is closest to the positive ideal solution, or ideal point, and farthest away from the negative ideal solution, or anti-ideal point.

The Positive Ideal Solution is the only one that maximizes the most advantageous ranking of each criterion, while the Negative Ideal Solution is the one that minimizes the ranking of each criterion. (Souza et al., 2018)

Souza et al. (2018) implements the method for prioritizing a project for an information technology investment portfolio. Colombo et al. (2019) performs the selection of the best oil well configuration for field development.

2.3 Application of Multi-criteria Decision Support in Finance

The research was conducted on the Scopus database and an analysis was performed using the VOS VIEWER on studies involving multi-criteria methods. The research on the platform was performed with the following parameters:

(TITLE-ABS-KEY (valuation) OR TITLE-ABS-KEY (investment) AND TITLE-ABS-KEY (multi-criteria) OR TITLE-ABS-KEY (mcdm) OR TITLE-ABS-KEY (mcda)).

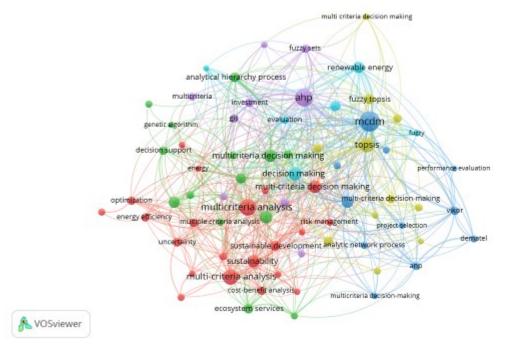Using the VOS VIEWER platform, we have the following result in figure 1:

Figure 1: Initial Scopus research result

Source: Authors (2021)

In the macro scenario, we can analyze the applications of multi-criteria decision support (MDA) tools in the most diverse application areas, and, within the investment area, we can see in renewable energy, project selection, sustainability, among others.

The analysis of the research was conducted in clusters. As far as this study is concerned, it is important to focus on the cluster identified by the blue color in the image. In it, we address the link between investments (given by investment), and the applications of studies using AMD tools. In this cluster, we can also see applications in economics and social effects, environmental impacts, and energy efficiency.

Figure 2 shows the analysis of the countries where most publications are made on the related subjects:
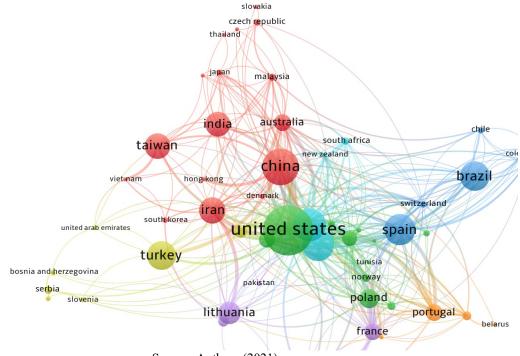
Figure 2: Analysis of the research by countries

Source: Authors (2021)

In this scenario, as expected, the United States and China lead the publications on multi-criteria applications in the areas of investments and evaluation of companies. Brazil is in a prominent position when compared to other countries such as Spain, Turkey, and others.

In an analysis of the most used keywords in this bibliographical research, the relationship between three main keywords can be observed: Multi-criteria Analysis, Decision Making, and Investments. From there, applications in the most diverse areas of knowledge

and in the most diverse AMD tools are dismembered, as observed in figure 3:
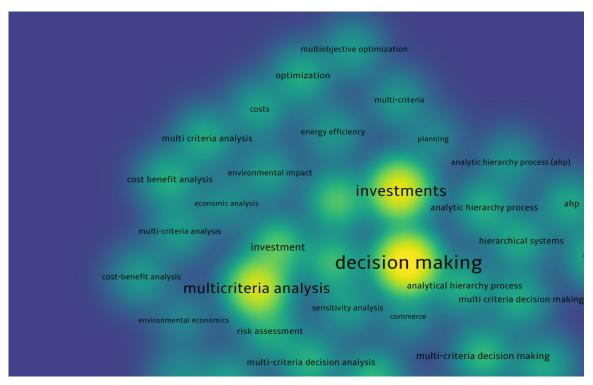
Figure 3: Relationship between Investments x AMD

Source: Authors (2021)

Still on the AMD applications in Finance, we can observe the following studies developed on various application methods and tools.

In Albadvi & Chaharsooghi (2006), the PROMETHEE method (using DECISION LAB software) is applied for portfolio selection considering the fundamental analysis of companies listed on the Tehran Stock Exchange (Iran Stock Exchange). The method was applied in two steps. Initially, it was used to select the companies that would compose the portfolio based on industry classification. Afterward, PROMETHEE was used to sort the companies selected at first according to their financial criteria. The main criteria used to evaluate the company were Price/Earnings, Profit Margin, Beta, Free Float, and Dividend Yield.

Basilio et al. (2018) utilizes the PROMETHEE II method to select an investment portfolio consisting of IBOVESPA stocks. The criteria used for company valuation were Price/Earnings, Company Value, Price/EBIT, ROE, and ROIC.

In Bana and Costa & Soares (2004), the selection of investment portfolios is

performed using direct classification, MACBETH, and optimization methods. The Dow Jones Eurostoxx50 was defined as the benchmark, and the main criteria used were Price/Earnings, and Earnings/Share. The MACBETH method was used to select the stocks and, lastly, to use optimization models to form the investment portfolio according to the risk-return ratio.

Leão Lyrio et al. (2015) employed AMD by using MACBETH for the formation of an investment portfolio composed of IBOVESPA stocks. The application of the method considered technical and fundamental analysis criteria. The main criteria used were Debt over Total Liabilities, Net Margin, EBITDA Margin, ROE, Price/Earnings, Price/Equity Value per Share, and Dividend Yield.

3. METHODOLOGY

The methodology of this research consists of the elaboration of a theoretical framework on indicators for Decision Making in Finance and on the AHP-TOPSIS-2N multi-criteria method. For the elaboration of the paper, a simulation was carried out with the companies' real data referring to the 2nd quarter of 2021. Data were obtained from the mining and steel sector shares traded on BOVESPA. Among the companies in the sector, the companies Bradespar (BRAP4) and Metalúrgica Gerdau (GOAU4) were removed from the study, since they are Holdings that invest through equity participation in other companies of the sector. For example, Bradespar's portfolio consists mostly of VALE shares (VALE3, already present in the study), while Metalúrgica Gerdau (GOAU4) has a larger stake in the shares of Gerdau (GGBR4, also already present in the study).

The AHP-TOPSIS-2N method was used to sort the shares according to the following criteria: Price on Earnings, Price on Book Value, Dividend Yield, Enterprise Value/EBITDA, and Return on Equity. For the attribution of the weights of the matrix of pairwise comparisons of the evaluation criteria, specialists in the financial area were consulted. The calculations of AHP-TOPSIS-2N were performed by the software Three Decision Methods (3DM) Web Software (v.1), developed by Bozzy et al. (2020)

4. ACHIEVED RESULTS

Table 3 presents the top thirty shares in order of liquidity, along with information on P/L, P/VP, and Dividend Yield. EV/EBITDA and ROE for each of them.

Table 3: Mining and Steel Sector Companies

	Price/Profit	Price/Book Value (or price to book ratio (P/B))	Dividend Yield	Enterp. Value/EBITDA	Return on Equity.
CMIN3	8.45	3.82	0.057	4.3	0.452
CSNA3	5.89	4.25	0.015	5.02	0.723
GGBR4	10.88	1.45	0.028	6.23	0.134
USIM5	11.78	1.56	0.007	4.87	0.132
VALE3	10.67	2.89	0.078	3.89	0.271
AURA33	8.79	3.1	0.068	5.57	0.353

Source: Fundamentus (2021)

For the P/L, P/VP, and EV/EBITDA criteria, we sought to minimize the values (the lower, the better). For the Dividend Yield and ROE criteria, the highest values were sought (the higher, the better).

Table 4 shows the matrix of paired comparisons of the evaluation criteria. In it, each pair of items was evaluated according to the opinion of experts in the field of Finance according to Saaty's numerical scale (Table 1). Values such as 1/3, 1/5, 1/7, and 1/9 denote situations in which item i is less important than item j.

Table 4: Matrix of paired comparisons of evaluation criteria

	P/L	P/VP	DIV.YIELD	EV/EBITDA	ROE
P/L	1	9	5	9	3
P/VP	1/9	1	1/5	1	1/3
DIV.YIELD	1/5	5	1	5	2
EV/EBITDA	1/9	1	1/5	1	1/5
ROE	1/3	3	1/2	5	1

Source: Authors (2021)

An analysis was performed to verify the occurrence of inconsistencies in the opinions expressed by the experts in the matrix of paired comparisons of the evaluation criteria (Table 5). Since the RC showed a value less than or equal to 0.10, the matrix is within the acceptable inconsistency limit.

Table 5: Consistency Analysis

Lambda(λ)	Mean Random Inconsistency (MRI)	Consistency Index (CI)	Consistency Ratio (CR)
5.1897	1.12	0.0474	0.0423

Source: Authors (2021)

After assigning the values in the matrix of paired comparisons of the criteria (Table 4), an analysis of the application of the method is performed using two normalization models. The goal is, by means of standardization, to substantiate and provide greater consistency in the results obtained. With this, we have the results below (Table 6):

Table 6: Results of procedure 1.

Alternative	Score Obtained	Rank
CMIN3	0.6037	1
CSNA3	0.5983	2
AURA33	0.5875	3
VALE3	0.4945	4
GGBR4	0.2091	5
USIM5	0.0816	6

Source: Authors (2021)

With the first normalization process, we can see CSN Mineração (CMIN3) assuming the first place in the sorting of the model. However, at a close proximity to CSN (CSNA3), AURA takes the third position with close proximity to CSNA3, but at a greater distance to CSN Mineração.

In the Group below, we have VALE3, GGBR4, and USIM5, assuming less attractive values in the valuation.

Concluding the application of the model, the result of the second normalization is presented, with the intention of validating the application and giving consistency to the business evaluation model (Table 7).

Table 7: Results of Procedure 2.

Alternative	Score Obtained	Rank
CSNA3	0.7389	1
CMIN3	0.5787	2
AURA33	0.5380	3
VALE3	0.3519	4
GGBR4	0.1844	5
USIM5	0.0825	6

Source: Authors (2021)

In the second normalization, we can observe CSN reaching the first position in the ranking. In the first procedure, we can verify almost a tie in the score obtained between the first two positions. In procedure two, a greater prominence of the first place can be observed. Still, the other placements did not change, which provides consistency in the application of the method and the tools.

5. CONCLUSION

The use of the AHP-TOPSIS-2N has proven applicable to the evaluation of companies within the analysis by multiples and within the fundamental analysis, sorting the companies of a given sector according to pre-established criteria. The use of the method contributed to a critical analysis, thus supporting the decision-makers.

Of the shares linked to the mining and steel sectors, CSN stood out in the sector. Both the mining and steel segments were prominent in the study. In the first normalization, CSM Mineração stands out, while in procedure 2, CSN takes the first position in the ranking. Despite being companies of the same group, they are exposed to different areas of activity. The study places them in the same sector because they are exposed to the price and trading moment of iron ore, as are the shares of GERDAU (GGBR4), VALE (VALE3), and USIMINAS (USIM5).

The study of the sector is very promising due to the fact that Brazil is one of the world's leading countries in the exploration and commercialization of iron ore. In the pandemic scenario, we had historic advances in the price of ore, which favored exports. A large part of the country's Gross Domestic Product is generated by the export of this commodity.

It is suggested, for future research, the extension of the study to other sectors, such as Oil, Energy, Transportation, and others that have large trading volumes on the Brazilian stock exchange.

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