Stock selection using a multiple criteria hierarchical process in the Dow Jones index

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Abstract: One of the problems that investors often face is deciding on the stocks to include in an investment portfolio. The objective of the paper is the selection of investment portfolios considering the 30 main companies listed on the New York Stock Exchange of the Dow Jones Index. Portfolio selection in this index is carried out by generating a previous ranking of the shares with a novel approach that analyses the performance of the shares in a multiple criteria hierarchical process (MCHP). The ordering is generated with the hierarchical version of the ELimination Et Choix Traduisant la REalité (ELECTRE) III method using different decision criteria based on financial ratios.

Keywords: portfolio selection; Dow Jones; Markowitz model; profit and risk; MCHP; multiple criteria hierarchical process; muticriteria ranking; ELECTRE III.

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1 Introduction

The evolution of financial theory has been conceived to financial management from different angles. The importance of financial management is evident in managing, addressing, and resolving the debt vs. profitability dilemma to provide the necessary resources at the right opportunity to take the measures that make such management more efficient and to ensure the financial returns that enable the growth of the company. Pucheta-Martínez (2015) define it as the science that is responsible for the study of how managers make decisions regarding financing and investment strategies that have as a fine value maximising the value of the organisation. Finance can be said to be the art and science of managing money, so financial management helps plan, produce, control, and direct the economic life of organisations.

The main problem to be addressed when referring to the stock exchange is risk. Concerning stocks, the aspect to consider when transferring risk is hedging, insurance and diversification. Bodie and Merton (2003) mention that diversification maintains some level of risk in many assets instead concentrating the entire investment on a single asset, therefore diversification limits risk exposure for any individual asset. Diversification reduces risk. Markowitz's mean variance model establishes the generation of an investment portfolio with various risk assets, reducing the risk because of diversification, without any reduction in its expected return. In Bay et al. (2017) we can find an extension of this Markowitz model. Other extensions are focused on the maximum individual risk (Teo and Yang, 2001), the marginal risk (Zhu et al., 2010), the probabilistic risk (Sun et al., 2015) and the cardinality constraint (Sun et al., 2013; Tian et al., 2016).

Traditional tools do not consider that the decision maker faces more and more complex scenarios with an increasing number of factors characterised by uncertainty (not only financial risk), the influence of different economic, social, environmental factors and the existence of a growing number of conflicting criteria to consider (Guerrero-Baena et al., 2014).

In a multi-criteria analysis approach, it is important to consider the decision-maker's preferences, such as portfolio selection (Ehrgott et al., 2004). The investor may present different preference in relation with another investor. The investor can show more or less risk aversion, the perception of the relative importance of various criteria. Diversification for the risk of individual assets is closely related to the risk behaviour of investors (Basilio et al., 2018). In this sense, analytical tools are required to meet the new demands in decision-making processes.

In the multi-criteria analysis approach, it evaluates the decision alternatives considering multiple factors or attributes. The main characteristic corresponds to the fact that it considers the preferences of the decision maker. In this approach, it is common to evaluate all the decision criteria at the same time. This corresponds to a single level, however, in problems with several criteria it is common to find groups of criteria that evaluate specific concepts of the problem. This type of analysis corresponds to evaluating

the alternatives in different groups of criteria at different levels of a hierarchical structure such as the proposal by Corrente et al. (2012). Stock evaluation seems to have just this characteristic, where one set of criteria is evaluating performance and another group of criteria is evaluating risk. Various groups of criteria can be added or analysed to this evaluation.

The evaluation of shares in the Stock Exchange is through many indicators. For this kind of problem, a multidimensional approach as the multi-criteria decision-making (MCDM) is necessary to consider many criteria at the same time to compare the shares. The MCDM provides various methods that support the indicators and evaluate the shares. Due to the limitation of the human capacity to handle that many information in needed some methods considering various criteria simultaneously. In the MCDM methods, some approaches based on full aggregation, outranking, goal aspiration or reference level, and non-classical are presented (Alvarez et al., 2021). The present work's applied method is the ELimination Et Choix Traduisant la REalité (ELECTRE) III. It is adequate for the stock selection problem. It presents a useful adaptation for different attribute values and the flexibility to adapt the decision-maker preference.

This research is focused on the stock selection considering financial indicators of 30 companies that make up the Dow Jones index, as they are the most important in the New York Stock Exchange (NYSE). Thus, the problem of the selection of actions is approached as a hierarchical multiple criteria process, due to the natural hierarchy that the problem of selection of actions presents in its criteria, considering seven macrocriteria: market, results operation, market value ratios, financial and economic profitability, liquidity, effectiveness, and dividends, for the optimal evaluation of the different stock selection.

The paper is organised as follows: Section 2 presents the literature review. The methodology of the multi-criteria hierarchical process and the hierarchical version of the ELECTRE III method is addressed in Section 3. In Section 4, the performance of the actions of companies with the hierarchical ELECTRE III method is analysed. Finally, in Section 5 the conclusions are shown.

2 Decision-making in the stock exchanges

In 1790, the stock exchange in New York (NYSE) emerged, during all this time it has had a steady growth. The top 30 industrial securities quoted on NYSE are represented by the Dow Jones index, this is calculated using the simple arithmetic average of prices. Dow Jones 30 companies can mark market-wide movements, as it is a very powerful indicator of the US economy and investor confidence in certain securities. As a global leader, NYSE is the place where investors come to access capital and participate in global markets. NYSE is a unique model that minimises execution risk and stock price volatility. Today, it remains the world's largest stock exchange, at the end of the First World War, surpassing the London Stock Exchange. Chahuán (2018) mentions a positive correlation with the Dow Jones index and other stock exchanges, such as Chile, where the index has a greater correlation with revenue than with company s results.

The importance of decision-making when making an investment and forming of a portfolio, allows to maximise profits and minimise the risk of investors. Useche (2015) mentions the contribution of financial institutions to conduct more appropriate advisory

processes, which respond more accurately to the needs of investment clients, with alternatives that truly fit their specific personal expectations and interests.

Markowitz is the model mostly applied in the portfolio theory of finance. The latest study confirms, to know the model in depth and compare the results to the different stock market index in order to analyse the effect of an efficient diversification on the performance and the risk of a portfolio (Perelló-Fons and Climent-Serrano, 2020). Studies conducted establish, prove the negative relationship between the centrality of assets in this financial market network and their optimal weights under the Markowitz framework (Peralta and Zareei, 2016). An efficient frontier in the typical portfolio selection problem provides an illustrative way to express the tradeoffs between return and risk (Xidonas et al., 2017).

On the other hand, application of financial ratios is considered as a tool for analysis and decision-making. Finding the relationship that capital-intensive firms have higher debt ratios than companies. Also, this study finds the existence of a strong inverse relationship between profitability and the amount of debt in the capital structure of capital-intensive firms (Quintiliani, 2020). Portfolio optimisation involves the optimal assignment of limited capital to different available financial assets to achieve a reasonable trade-off between profit and risk (Lwin et al., 2017).

In the face of globalisation of markets, diversification of investment in different markets at the international level is necessary. It takes place investment strategies by investors, We believe these findings are relevant to the investors for the purpose of international portfolio diversification and developing investment strategies at times of turbulent economic conditions (Das et al., 2019). The importance of decision makers in organisations is relevant to the work of CEOs. In addition, the share price has an impact. The correlations between CEO salary, CEO total compensation, and firm size were ranged from weak to good positive ratios (Nulla, 2013).

The using other decision-making tools, such as MultiCriteria Decision Aid (MCDA) for better analysis and in-depth analysis, on the part of financial brokers. The financial indicators show negligible differences across firms in many cases conveys a compelling argument for the accrued value, and central role, of qualitative information -market and management- in the decision-making process, notably using a MCDA model (Soares and Pina, 2014). The use of MCDA allows us to generate a multicriteria ranking to establish investment strategies, as studies conducted. The confirmed the strong position of Scandinavian countries for assuring best sustainability practices in financial institutions and in the economy (Ziolo et al., 2019).

The study presents a multiobjective approach that involves fuzzy parameters, where the distributions of possibilities are given by fuzzy numbers of the information and the investor's preferences are explicitly incorporated through the concept of satisfaction functions. Greco et al. (2013) mention the selection of an investment portfolio in a different way from the Markowitz model and use the MCDA method in the evaluation of portfolios for a multi-objective optimisation problem. The Markowitz mean variance model was implemented in a portfolio optimisation model (Ehrgott et al., 2004) in the Standard and Poor's database of 1108 investment funds.

Aldalou and Perçin (2018) analysed airlines listed on the Istanbul Stock Exchange with Fuzzy AHP for weights definition and Fuzzy TOPSIS to rank the airlines. On the other hand, Mohammad et al. (2012) analysed eighteen top companies from different TSE industries thorough the TOPSIS method.

Zopounidis et al. (1998) applied the UTADIS method for the portfolio selection problem. In the study, a predefined ordering of a set of reference stocks was used to support the decision-making process, 98 stocks were evaluated with 15 criteria.

Sánchez et al. (2010) applied the AHP method on four Argentine companies with five types of financial indices: the profitability, activity, liquidity, solvency, and market value. The decision criteria used were return on investment, earnings per share, price/earnings, beta index, asset turnover ratio, trading times, return on assets, return on equity and liquidity.

A comparison of some methods was performed by Pätäri et al. (2017). In the study, they compared median scale, TOPSIS, AHP, and DEA evaluating performance of US stocks. Altınırmak et al. (2016) used AHP to define the criteria weights and the PROMETHEE method to rank investment trusts in securities traded from Turkish stock index.

Albadvi et al. (2006) applied the PROMETHEE method in the Tehran Stock Exchange. The evaluation includes industrial sectors and their respective companies in the sector. Basilio et al. (2018) applied the principal components analysis and the subsequent PROMETHEE II method to compare the assets in terms of their performance in the financial indicators (criteria) on the set of shares traded on the São Paulo stock exchange.

Lima and Soares (2013) selected asset with ELECTRE III method for portfolio selection in a purchase and retention strategy, and to test if it exceeds the market measured by the Portuguese Market Index. The financial ratios used were return on equity, indebtedness, general liquidity, with the weighting of each. Vezmelai et al. (2015) select and classify 20 companies with the ELECTRE III method and compared to the ranking offered by the Tehran Stock Exchange.

Boonjing and Boongasame (2017) propose a combinatorial portfolio selection with the ELECTRE III method to support small investors in their investment decision. Xidonas et al. (2009) applied ELECTRE III to sort into 8 different classes corresponding to each sector or industrial activity to integrate a Pareto investment portfolio. Multiple criteria decision aid (MCDA) methods have been applied to address the problem of portfolio selection; the ELECTRE III method uses the MCDA methodology applied to the problem of finance and portfolio selection (Govindan and Jepsen, 2016; Spronk et al., 2016).

3 Methodology for the selection of actions

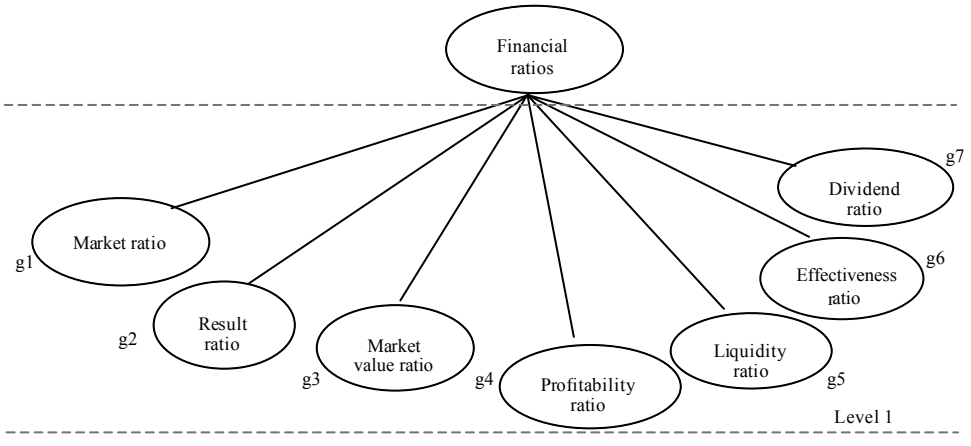
One of the basic characteristics of multicriteria analysis is to compare alternatives based on a series of criteria. Therefore, multicriteria ordering methods are designed to build a recommendation on a set of alternatives according to the preferences of the expert or decision maker. The MCDA provides a structured framework for basic task of decision-making (Bui and Jarke, 1986). For the current problem, non-probability sampling is applied by criterion, considering that they are the most representative of the NYSE. The Dow Jones index is made up of 30 companies representing different economic sectors, generating returns in the market; this represents a stock index that tracks the performance of America's largest companies. It is considered a financial barometer used by brokerages at a global level, which use as a reference with which the relative performance of individual stocks can be measured.

3.1 The multiple criteria hierarchy process to evaluate assets

The MCDA process develops the definition of a set of alternatives $A=\{a_1,a_2,..,a_m\}$ and a coherent family of criteria $G=\{g_1,g_2,..,g_m\}$. Any MCDA method develops preference aggregation process in one of the decision problematics: ranking, sorting or selection of alternatives.

The first stage of the portfolio selection problem consists of generating a stock evaluation ranking. The classic MCDA method will analyse NYSE stocks at the same level, evaluating all criteria at the same time. Figure 1 shows this classic form of analysis of the performance of stocks at the same level. In the problem of the selection of actions there is many criteria, even among them they can be grouped into categories of criteria that concentrate evaluation subcriteria. It is well known that evaluating stock selection requires various types of information commonly addressed from the Dow Jones indexes.

Figure 1 Flat structure of the decision-making problem



The multicriteria analysis at a single level in the generation of an ordering of shares as an initial stage for the selection of portfolios, limits to only evaluating the performance of the shares, and it is not allowed to understand how some subcriteria (indices) interact with each other to show the performance of a category at a higher level (e.g., market ratio).

However, it is possible to analyse the problem of ordering actions as a multiple criteria hierarchy process (MCHP), to analyse the problem of financial ratios (evaluation of actions) in subgroups of criteria and analyse the interaction that they present a subset of criteria in relation to the category to which they belong.

It often happens that a practical application is imposing a hierarchical structure of criteria (Corrente et al., 2012). To address decision-making problems where evaluation criteria are considered at the same level, instead, a hierarchical structure is used to organise them into one part of the problem. The basic idea of MCHP is based on the consideration of the preference relationships at each node of the hierarchical criteria tree. These preference relationships refer both to the phase of obtaining information on preferences and to the phase of analysis of a final recommendation by the decision maker (Corrente et al., 2012).

A hierarchical criteria structure can be viewed as a criteria tree. The structure of the tree takes a particular interest on the part of the expert or decision maker and agglomerates a subset of criteria in sheets (macrocriteria). The sheets are breaking down the problem into smaller problems to understand the interaction in elementary criteria (subcriteria of the lowest level of the hierarchy). Figure 1 deals with a multi-criteria decision aid problem that evaluates criteria at the same level. However, the same problem can be analysed in smaller problems, such as a hierarchy problem. Figure 2 illustrates a tree criteria structure; some leaves contain branches with more leaves making a tree of secondary problems. Corrente et al. (2017) integrate the MCHP with the ELECTRE III method (Roy, 1990) and Álvarez et al. (2020) developed a computational tool available on GitHub (https://github.com/pavelalvarez/hierarchy-ELECTREIII). Some of the most important notations are explained as follows.

G is a comprehensive set of all criteria at all considered levels in the hierarchy.

G_0 is the root of the criterion.

l_G is the set of indices of the criteria in G.

$E_G \subseteq l_G$ is the set of indices of elementary criteria.

g is the generic non-root criterion (where *r* is a vector with length equal to the level of the criterion).

$g_{(r,1)},\ldots,g_{(r,n(r))}$ are the immediately subcriteria of criterion g_r (located at the level below g_r).

$E(g_r)$ is the set of indices of all the elementary criteria descending from g_r.

$E(F)$ is the set of indices of the elementary criteria descending from at least one criterion in the subfamily $F \subseteq G$ (that is, $E(F) = U_{g_r \in} E(g_r)$).

G_r is the set of subcriteria of g_r located at level 1 in the hierarchy (below g_r).

To better understand the above notation, it can be seen in the hierarchical structure of Figure 2, where Level 1 contains the macrocriteria and the elementary criteria that descend from these are decomposing the subproblem. The entire set of elementary criteria is contained in E_G. As shown in Figure 2, a different approach to the multi-criteria decision aid problem can be implemented when generating a hierarchical structure with respect to the criteria of interest at a particular level of the hierarchy.

The problem of selecting stocks to integrate a portfolio can be approached as a hierarchical problem, where some macrocriteria can integrate elementary criteria from a deeper level of the hierarchy. Figure 3 illustrates a summary structure (two macrocriteria) of the entire hierarchical problem of stock selection for the Dow Jones Index. The macro criterion Market ratio g_1 integrates 6 elementary criteria, Ratio of results g_2 integrates 8 elementary criteria among others, up to the macro criterion Dividend ratio g_7 that integrates 6 elementary criteria. The evaluation of the shares of the Dow Jones index

includes 47 elementary criteria and is structured in a two-level hierarchy, in the first level 7 macrocriteria are defined (non-elementary criteria). At Level 2, 47 elementary criteria constitute the macrocriteria of Level 1.

Figure 2 Structure of the problem in the multi-criteria hierarchy process (see online version for colours)

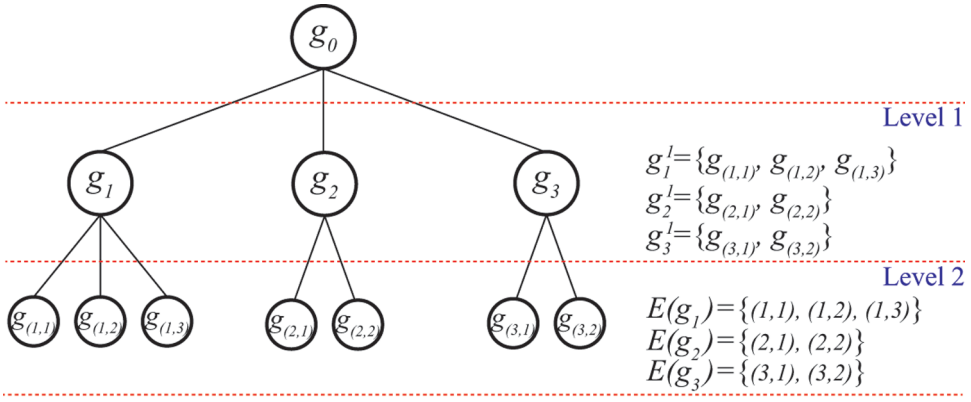
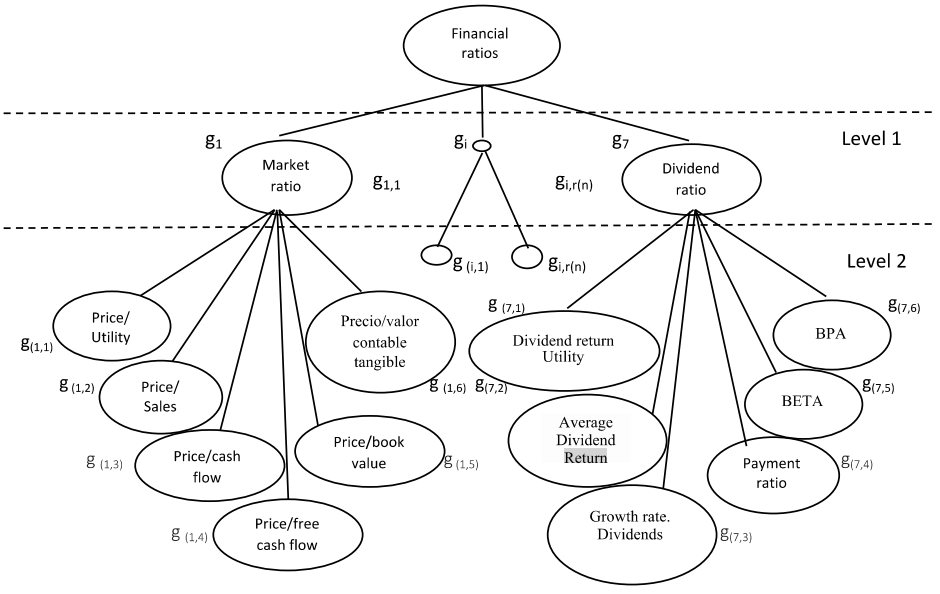


Figure 3 MCHP's simplified structure for NYSE stock selection



The problem of analysing the performance of NYSE shares can be addressed as MCHP. The criteria for evaluation of the NYSE shares present seven categories, these can be considered as groups of subcriteria (see Figure 3). This situation is frequent because in the case that a practical application imposes a hierarchical structure (Corrente et al., 2012). In this sense, a different method for evaluating actions by subset of criteria would be valuable. As the MCHP to solve the stock selection problem. For this reason, the analysis of the hierarchy of criteria is proposed to generate a ranking of NYSE stocks.

3.2 ELECTRE III hierarchical method

The ELECTRE III method was proposed by Roy (1990), from an approach to help the decision with overcoming relationships, the method includes the preferences of the decision maker in the proposed solution. This method is pertinent to the proposal presented here since it is considered that the evaluation of the shares must consider the preferences of the investor. Therefore, the decision maker must define certain parameters including thresholds and importance values (*q, p, v, w*) of the criteria. These are included in a non-compensatory relational function that generates fuzzy values (σ) to evaluate the actions, precisely this fuzzy valuation allows evaluating a certain subjectivity of the investor to evaluate if one action is superior to another.

The hierarchical ELECTRE III method was introduced by Corrente et al. (2017). The ELECTRE method aggregates decision-makers' preferences building a model in the valued fuzzy relationship. For each elementary criterion $g_t \in E_g$.

The elementary concordance index, for each elementary criterion g_t

$$\phi_t(a,b) = \begin{cases} 1 & \text{if} \quad g_r(b) - g_r(a) \le q_t, (aS_tb) \\ \dfrac{p_t - [g_r(b) - g_r(a)]}{p_t - q_t} & \text{if} \quad q_t < g_r(b) - g_r(a) < p_t, (bQ_ta) \\ 0 & \text{if} \quad g_r(b) - g_r(a) \ge p_t, (bP_ta) \end{cases} \tag{1}$$

The elemental discordant index, for each elemental criterion g_t

$$d_t(a,b) = \begin{cases} 1, & \text{if} \quad g_r(b) - g_r(a) \ge v_t \ , \\ \dfrac{[g_r(b) - g_r(a)] - p_t}{v_t - p_t} & \text{if} \quad p_t < g_r(b) - g_r(a) < v_t \ , \\ 0, & \text{if} \quad g_r(b) - g_r(a) \le p_t \end{cases} \tag{2}$$

The partial concordance index for each non-elementary criterion g_r

$$C_r(a,b) = \frac{\sum_{t \in E(g_r)} w_t \phi_t(a,b)}{\sum_{t \in E(g_r)} w_t} \tag{3}$$

Partial credibility index

$$\sigma_r(a,b) = \begin{cases} C(a,b)\ x \prod\limits_{g_t \in E(g_r)} \dfrac{1 - d_t(a,b)}{1 - C_r(a,b)} & \text{if} \quad d_t(a,b) > C_r(a,b) \\ C(a,b) \end{cases} \tag{4}$$

In the second step, the valued overcoming ratio is exploited by the distillation process, generating a partial or complete ranking of alternatives that is explained as follows. The valued improvement ratio generated in the previous step corresponds to the decision maker's preferential model. The distillation method is used to exploit the preferential model. The distillation proceeds in a descending and ascending way; therefore, the final pre-order is obtained as the intersection of the two distillations. A general description of the distillation method is described in Giannoulis and Ishizaka (2010). For the pair

$a,b \epsilon A$ in the hierarchical process, the alternatives are ordered in a partial or complete pre-order for each non-elementary criterion g_r as follows:

aP_rb. a is strictly preferred to b in the macro criterion g_r if in at least one of the rankings, a is placed before b, and if in the other ranking a is at least as good as b.

aI_rb. a is indifferent to b in the macro criterion g_r if the two actions belong to the same position in the two pre-orders.

aR_rb. a is incomparable to b in the macro criterion g_r if a is ordered better than b in ascending distillation and b is better ordered than a in descending distillation or vice versa.

4 Analysis of Dow Jones stocks with the multi-criteria hierarchical process

The NYSE data is used in this work with a new approach, the Multiple Criteria Hierarchy Process (MCHP) to analyse the performance of the stock, but with respect to the interaction of criteria subgroups at different levels in a hierarchy through of the ranking. The Dow Jones companies are listed in Table 1.

Table 1 Dow jones index companies

Label	*Company*	*Label*	*Company*
A1	Merck	A16	Johnson & Johnson
A2	3M	A17	JPMorgan Chase
A3	American Express	A18	McDonald's
A4	Apple	A19	Microsoft
A5	Boeing	A20	Nike
A6	Caterpillar, Inc	A21	Pfizer
A7	Chevron Corporation	A22	Procter & Gamble
A8	Cisco	A23	The Travelers Companies
A9	Coca-Cola	A24	United Technologies
A10	DuPont	A25	UnitedHealth Group
A11	ExxonMobil	A26	Verizon Communications
A12	Goldman Sachs	A27	Visa
A13	Home Depot	A28	Wal-Mart
A14	IBM	A29	Walt-Disney
A15	Intel	A30	Twitter

The analysis is performed based on the financial statements for the first quarter of this year, obtained from the Investing financial portal compiled from the NYSE that generates a performance index that informs the companies of the Dow Jones Index and shows the existing capacities for investors. The financial ratios are taken to select the macrocriteria that allow evaluating the performance of each company (see Table 2), these give indications about its financial situation and prospects for its performance, as well as the

evaluation of the position of a company compared to others. Table 2 shows the decision criteria of the shares evaluation problem. Here it is listed in the first level the macrocriteria names ($g1$, $g2$, …,$g7$), at second level the elementary criteria ($g1,1$, …, $g7,6$). The last column list the weights of the elementary criteria.

Table 2 Macrocriteria and elementary criteria for the selection of shares

Index	*Macrocriteria*	*Index*	*Elementary criteria*	*Weight*
g1	Market ratio	g1,1	Price/earnings ratio (12 months)	0.0558
		g1,2	Price/sales (12 months)	0.0372
		g1,3	Price/cash flow (most recent quarter)	0.0090
		g1,4	Price/Free Cash Flow (12 months)	0.0186
		g1,5	Price/book value (most recent quarter)	0.0465
		g1,6	Tangible price/book value (most recent quarter)	0.0279
g2	Results ratio	g2,1	Gross margin (12 months)	0.0302
		g2,2	Gross margin (5 year average)	0.0194
		g2,3	Operating margin (12 months)	0.0121
		g2,4	Operating margin (5 year average)	0.0157
		g2,5	Margin before tax (12 months)	0.0229
		g2,6	Margin before tax (5 year average)	0.0266
		g2,7	Net margin (12 months)	0.0339
		g2,8	Net margin (5 year average)	0.0084
g3	Market value ratio	g3,1	Benefits/share (12 months)	0.0434
		g3,2	Basic earn per share (Annual)	0.0493
		g3,3	Diluted earn per share (Annual)	0.0376
		g3,4	Book value/most recent quarter share	0.0258
		g3,5	Tangible Book Value/most recent quarter share	0.0141
		g3,6	Cash/share (most recent quarter)	0.0200
		g3,7	Cash flow/share (12 months)	0.0318
g4	Profitability ratio	g4,1	Financial profitability (12 months)	0.0222
		g4,2	Financial profitability (5 year average)	0.0190
		g4,3	Economic profitability (12 months)	0.0031
		g4,4	Economic profitability (5 year average)	0.0095
		g4,5	Return on equity (12 months)	0.0063
		g4,6	Return on investment (5 year average)	0.0286
		g4,7	Earn per share vs previous year	0.0158
		g4,8	Earn per share (12 months) vs previous year	0.0254
		g4,9	Sales (12 months) vs previous year	0.0127

Table 2 Macrocriteria and elementary criteria for the selection of shares (continued)

Index	*Macrocriteria*	*Index*	*Elementary criteria*	*Weight*
g5	Liquidity ratio	g5,1	Sales growth (5 year average)	0.0151
		g5,2	Capital expenditure growth (5 year average)	0.0030
		g5,3	Acid test (most recent quarter)	0.0090
		g5,4	Solvency ratio (most recent quarter)	0.0181
		g5,5	Long-term debt to equity (most recent quarter)	0.0120
		g5,6	Total debt to equity (most recent quarter)	0.0060
g6	Effectiveness ratio	g6,1	Asset turnover (12 months)	0.0240
		g6,2	Inventory turnover (12 months)	0.0180
		g6,3	Employee/benefit (12 months)	0.0120
		g6,4	Net income/employee (12 months)	0.0060
		g6,5	Turnover of accounts receivable (12 months)	0.0300
g7	Dividend ratio	g7,1	Annual dividend yield	0.0221
		g7,2	Average dividend yield (5 year average)	0.0166
		g7,3	Annual dividend growth rate	0.0110
		g7,4	Payment ratio (12 months)	0.0055
		g7,5	BETA	0.0277
		g7,6	Earn per share	0.0331

Data obtained from the NYSE is grouped into 7 dimensions used to evaluate stocks that are traded on the Dow Jones. In Table 2, each dimension corresponds to a macrocriterion in the hierarchy approach. Each dimension is made up of a subgroup of indicators (elementary criteria), in total there are 47 indicators to evaluate the actions of the 30 companies in the Dow Jones Index.

With respect to the methodology proposed in Section 3, the MCHP (Section 3.1) and hierarchical ELECTRE III (Section 3.2), the MCHP is applied to solve the problem of selecting stocks to integrate an investment portfolio. In the first step, the problem is structured in a hierarchy of multiple criteria, decomposing the problem into 7 macrocriteria as subproblems of the actions. As shown in the hierarchical structure in Figure 2, NYSE listed stocks are structured in a hierarchy with respect to the 7 macrocriteria and the 47 elementary criteria.

The new hierarchical structure for the equity performance problem allows the analysis to move closer to the MCHP. The analysis of each macro-criterion allows us to know the interaction of a subset of criteria directly related to the macro-criterion. Moreover, it is carried out by generating preferential models and rankings for each macro criterion to understand the performance between actions and the final ranking for the action selection.

Table 3 contains the rankings of each macrocriterion in Level 1. Each macrocriterion is evaluated by a subset of subcriteria (elementary criteria that belong to the last level of the hierarchy). The ordering generated is the result of the interaction of elementary criteria that evaluate the corresponding macrocriteria. For the problem of selection of actions, it was analysed how the interaction of the subset of elementary criteria influences the macrocriteria (Level 2 of the hierarchy).

Table 3 Individual ranking of company shares

Ranking	*g1*	*g2*	*g3*	*g4*	*g5*	*g6*	*g7*
1	A19	A21	A12	A20	A30	A18	A24
2	A22	A19	A23	A9	A20	A28	A26
3	A4	A1	A24	A4	A13	A4	A15
4	A9	A14	A17	A26	A19	A26	A13
5	A20	A8	A4	A1	A14	A29	A12
6	A16	A9, A16	A28	A21	A29	A13	A16
7	A30	A18	A6	A19	A24	A15	A18
8	A18	A3	A25	A14	A5	A20	A17
9	A1	A12	A3	A16	A4	A19	A2
10	A7	A26	A7	A28	A8	A8	A4
11	A28	A2	A15	A13	A16, A23	A7, A11	A28
12	A8	A15	A13	A15	A10	A22	A23
13	A21	A4	A11	A2	A25	A9, A14	A6
14	A14	A30	A19	A18	A17	A25	A1
15	A2	A22	A29	A8	A1	A2	A7
16	A6, A13	A20, A29	A2	A3, A6	A21	A24	A21, A22
17	A29	A13	A14	A29	A28	A6	A9
18	A24	A6	A16	A30	A18	A19, A16	A3
19	A3, A26	A7	A30	A24	A27	A5	A11
20	A25	A25	A5	A17	A22	A21	A8
21	A17	A11	A1, A10, A20, A26	A23	A12	A30	A29
22	A15	A17	A18	A25	A2	A3	A14
23	A11	A23	A8	A22	A3	A12	A25
24	A23	A10	A22	A12	A7	A17, A23, A27	A19
25	A12	A28	A21	A5	A6		A27
26	A5, A10, A27	A5, A24	A27	A27	A26		A10
27		A27	A9	A11	A11		A20
28				A7, A10	A9		A5
29					A15		A30

Analysing each of the macrocriteria that has been used to analyse the companies, there is not a company in the first position in more than one macrocriterion. These variations are important to consider because it is possible to identify how much the ordering can change if different parameters are used with the same information. In this sense, the rankings are not absolute, but you can change the preference and many other elements related to different quantitative parameters. Therefore, it is important to use methodologies that can be adapted to the reality of the decision maker, for the integration of an investment

portfolio, based on the financial indicators of the companies, and according to the profile and preferences of the investor.

The 30 shares are ranked in Table 4. The ranking corresponds to the comprehensive problem G_0 that includes the seven macrocriteria in Level 1 and the complete 47 elementary criteria (Level 2) at same time in the evaluation.

Table 4 Ranking of the Dow Jones index

Ranking	*Company*	*Ranking*	*Company*
1	A4, A19	13	A17
2	A12	14	A26
3	A13	15	A30
4	A18	16	A22
5	A15	17	A7
6	A6	18	A23
7	A21, A28	19	A29
8	A14	20	A25
9	A16	21	A11
10	A1	22	A5
11	A2, A3, A8, A20	23	A10
12	A9, A24	24	A27

The ranking shows Apple (A4) and Microsoft (A19) as the best evaluated from the Dow Jones stock exchange. Goldman Sachs (A12) is second position and McDonald's (A18) is in third position. The ranking of subset of criteria helps to understand the performance of each group of criteria. It is stated that Apple present good performance only in the rankings of the macrocriteria g1, g4 and g6. On the other hand, Microsoft in in the top position only in g1, g2 and g5. If an investor is more interested in a specific decision criteria (indicators) of the shares, the MCHP shows which companies are the best on each subset of criteria. The MCHP methodology helps to understand the interaction in relation of their performances between subset of criteria of each company.

5 Conclusions

The aim of the research is to evaluate shares in the New York Stock Exchange for stock selection. The process was carried out with a multi-criteria decision analysis method. It is the hierarchical version of the ELECTRE-III method, considering 47 financial indicators grouped in seven macrocriteria. They were used to rank the 30 companies in the Dow Jones index.

The application of the MultiCriteria Hierarchy Process (MCHP) in the evaluation of Stock Exchanges' shares allows the analysis of the interaction of subgroups of criteria in the stocks. It helps to understand, how some groups of indicators are impacting in positive or negative way the stock. An investor can be more interested in some groups of indicators and select stock that performs better in those subgroups of indicators, unlike the stock regarding the complete set of indicators.

The applied MCHP allowed the analysis of the stock's performance at two levels and ranked them. The ranking allows the selection of the best stocks regarding investor preferences. The stocks on the top of the ranking can be selected to form promising investment portfolio. For the problem of stock selection and preparation of investment portfolios, it shows the opportunities and weaknesses of the companies and allows a more robust and reliable decision making. The integration of the stock ordering and the construction of portfolios of the NYSE companies could be applied as an instrument in the formulation of more assertive policies and decisions within the organisations. Consequently, it would achieve favourable conditions to boost the investor.

For future lines of research, it is considered to analyse other areas of the social sciences and economic phenomena that minimise the degree of uncertainty in the decisions of managers of risk managers of investment portfolios, in the generation of models for the application with the application of linguistic variables (Liern and Pérez-Gladish, 2018).

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