Analytic hierarchy process applied on the stock exchange market: The Moroccan case

La méthode AHP appliquée aux marchés boursiers : Le cas Marocain

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Abstract

The multitude of the stocks in a financial market could make the investors puzzled when it comes to taking a decision. Indeed, finding the best choice of stocks that would make a good investment could be a very difficult process. In order to solve this difficulty, many researchers and financial analysts have developed during the last decades several methods of stock selection in order to guide capital holders to the best investment strategy.

This work based on the Analytic Hierarchy Process (AHP), which is a multicriteria decision making method, aims to classify publicly traded stocks on the Moroccan stock exchange from most to least interesting. First, a rigorous financial analysis will be performed for clearly identifying and carefully choosing ratios in order to use the maximum of information available on the shares. Then an empirical study will be established to provide a ranking of Moroccan companies by using AHP method, which would help investors to choose the most advantageous stocks.

Keywords: Multicriteria analysis; Analytic Hierarchy Process (AHP); Stock exchange market; Stock selection; Moroccan market.

Résumé

La multitude des actions dans un marché financier pourrait rendre les investisseurs perplexes quant il s'agit de prendre une décision. En effet, il pourrait être difficile de trouver les meilleurs choix constituant un bon investissement. Pour remédier à ce problème, plusieurs chercheurs et analystes financiers ont développé, durant les dernières décennies, diverses méthodes pour la sélection de titres boursiers, afin de guider les détenteurs de capitaux vers la meilleure stratégie d'investissement.

Ce travail basé sur la méthode AHP (processus d'analyse hiérarchique), qui est une méthode d'aide à la décision multicritère, a pour objectif de classer les entreprises cotées en bourse marocaine par ordre d'importance. Dans un premier temps, une analyse financière rigoureuse sera effectuée pour identifier clairement et choisir soigneusement les ratios afin d'utiliser le maximum d'informations disponibles sur les actions. Ensuite, une étude empirique sera réalisée pour obtenir un classement des entreprises marocaines à l'aide de la méthode AHP, ce qui permettrait aux investisseurs de choisir les actions les plus avantageuses.

Mots clés : Analyse multicritère ; Méthode AHP ; Marché boursier ; Sélection de titres ; Marché marocain.

Introduction

Risk is the counterpart of the probability of the gain. Investors cannot achieve a financial gain without taking a risk of loss, knowing that the risk is different from one share to another.

Generally, the higher the risk, the higher the expectation of profitability. For most decision makers, the choice of investment is a very delicate task; they usually use several methods and tools to determine the right choice. But the complication of the choice makes the task more difficult.

Considering the large availability of 'Alternatives' assets and the multitude of criteria to base our choice on, we must always analyze the meaning of each criterion, and how these criteria will help us choose one alternative over another? How will it contribute to our analysis? And how will it meet the needs of investors?

It is important to differentiate between two types of investors; risk-averse investors tend to seek investments with a very low risk, while risky investors like to take higher risks. In the first part of this paper work, we will discuss the most important multicriteria methods that exist, and we will explain why we choose the Analytic Hierarchy Process for our study case, showing its strengths and how it will contribute to our analysis.

We will also demonstrate the link between the Multicriteria decision aid and stock selection in order to show the importance of the use of such methods in the finance field, and how we are obliged to adopt new methods in our process of stock selection.

In a second part, we will choose the criteria we will use for the comparison between the alternatives selected for our study case. These criteria are selected after a long process of research in the fundamentals of companies and also market ratios. We decided that it is important to take into consideration both aspects; rations concerning the financial health of the company, and also financial market ratios that gives us the valuation of the company on the financial market and the perception of the market.

The Moroccan stock exchange market is our field of study. It had been a market in ongoing change and progress since the inauguration of the Casablanca stock exchange in 1929, especially after 1993 with enormous reforms. (Benjana, 2019) Showed in her paper untitled "PORTFOLIO MANAGER : A JOB WITH A PERPETUAL MOVEMENT" the changes the occurred in the past years, and how the portfolio managers jobs had been changing trying to keep up with the growing environment, our paper bring some solutions to these portfolio managers, it presents an opportunity to develop more skills in the stock selection field.

1. Review of multicriteria analysis methods

1.1. General review

In the American school the multicriteria analysis is called Multiple criteria decision making (MCDM), in the European school it's called multicriteria decision aid (MCDA). According to (Zopounidis,1999) the MCDA is a set of methods which allow the aggregation of several evaluation criteria in order to choose, rank, sort or describe a set of alternatives.

In the process of making a decision, we need to solve problems that include qualitative and/or quantitative criteria, the Multicriteria decision aid is a decision support tool developed to solve this kind of problems.

Establishing several criteria for making a decision can be confusing in the absence of a logical and well-structured decision-making process. The MCDA takes place to identify the importance of each criterion and its weight compared to the other criteria. It also allows us to take into account the preferences of decision makers too.

The MCDA helps the decision makers solve complex problems in different fields, the application of the MCDA on the financial market gave the investors tools to manage their portfolios, assess investment etc. Even if the is conflicting.

It is important to define the problem the decision maker needs to solve; it can be a choice problem, sorting problem, or ranking problem all according to (Roy & Vanderpooten ,1996)

Each problematic is adapted to a certain kind of decision process; decision makers must identify the type of the problematic so they can apply the adequate decision process.

ELECTRE methods, PROMETHEE, VIKOR, TOPSIS and AHP are all multcriteria decision making methods that were applied to a lot of fields, financial researchers took over the MCDA to solve the stock selection problem. Our previous work "Multicriteria analysis applied to stock portfolio selection: Theoretical framework" (Tahir & Kadiri, 2019) demonstrated the above methods and showed how they were used in the financial field.

In this work we will only focus on the Analytic Hierarchy Process (AHP) and how we can put into use for the financial decision making.

1.2. The Analytic Hierarchy Process (AHP)

One of the clearest methods of multicriteria analysis is the Analytic Hierarchy Process (AHP)

founded by a mathematician known for his valuable work, (Saaty ,1987). The AHP is a popular method, it's often used by decision makers in different fields such industry engineering etc.

The AHP is a process of choosing between several alternatives according to several criteria, each decision maker before making any decision, he tries to put forward the good reasons to make a certain choice, and the good reasons to decline another, so in a way, the decision maker tries to prioritize his options based on his needs and expectations. This means that the choice is based on a personal judgment. In this part, we will use the word factor or criterion to designate the factors on which we are going to base our choice, and alternatives or choices to indicate the options or proposals of solutions available.

Looking back to the work of the pioneer of the classical approach of the portfolio management Harry Markowitz (1952), we realize that the mean-variance (M-V) optimization model is criticized over time by researches. According to (Ekeland,1993) the problem of portfolio choice in the M-V model is a multicriteria one, because the investor will try simultaneously to maximize the return and minimize the risk; but determining the risk, one comes back to maximize the return, which is a classical monocriteria problem.

(Bouri et al, 2002) criticized as well the mean variance model. They stated that the utility function of the investors is not quadratic, neither the returns are normally distributed. In the other hand, we find that (Fama ,1965) claimed that the normal distribution is the closest to describe the distribution of the returns but with tick tales.

1.3. MCDA applied to stock selection

Facing a decision making problem in finance claims a combination of financial theory and the right tools such as multi-criteria decision making methods to answer the needs of decision makers and be able to solve the problems according to (Tahir & Kadiri,2019).

(Kazimieras Zavadskas Edmindas ,2011) Stated that the changing environment of economics conducted massive and rapid changes in OR, these changes and techniques were used to solve economic problems. Taking for example the Multicriteria decision making aid.

According to (Roy, 1988) these reasons were the foundation of the beginning of the use of multicriteria analysis in the finance field:

- Multiple criteria.
- Conflict situation between the criteria.
- Complex evaluation process, subjective and ill-structured.

- Introduction of financial decision makers in the evaluation process.

The multicriteria character of this financial problem pushes the investors to look for developed methods that take into consideration a variety of criterion.

According to (Zopounidis, 1999) MCDA contributed in a significant manner to solving several financial problems such as venture capital investment, business failure risk credit rating, bond rating, country risk, political risk financial planning and portfolio management etc.

There are several questions that must be asked to understand the value of using the MCDA, such as why decision making is a delicate process? Because there are several possible scenarios when making decisions, and there are several decision-makers trying to take the decision, we have also a multitude of criteria that we have to take into consideration.

Decision makers should not ignore the fact that the consequences of the decision making are uncertain and irreversible.

Why do we use MCDA in stock valuation? To eliminate the increased risk of making a wrong decision. MCDA gives the decision maker the opportunity to incorporate a lot of criteria into the analysis, this could facilitate investor's decision making according to the importance of each criterion or indicator, and diminishes the fact that they may ignore one of factors of loss or gain.

(Zopounidis ,1999) claims that we can distinguish three main reasons which have motivated a change of view in the modeling of the financial problems:

- Formulating the financial problem in terms of seeking the optimum, financial decision makers get involved in a very narrow problematic often irrelevant to the real decision problem.

- The humans are involved in the financial decision, it becomes necessary to take into account their preferences, experiences, and knowledge.

- When it comes to take a financial decision, such as the choice of an investment projects, or portfolio selection, it seems illusory to speak of optimality since multiple criteria must be taken into consideration.

1.4. Why using the AHP

The AHP is an elegant method that allows us to rank the alternatives and conduct a process of analyzes using conflicting criteria. The AHP takes into consideration the subjectivity of

investors' opinions, regarding the choice of criteria and their weight. Two different people can choose different criteria and different alternatives and those to meet the same objectives; there are no good criteria or bad criteria because it comes from a subjective opinion, the importance of each criterion changes from a decision maker to another.

AHP method is a special process that divides the problems into a hierarchy of an overall objective, criteria, subcriteria, sub-subcreteria according to (Steuer & Na ,2003), which makes the problem easier to process.

2. Methodology

2.1. Necessary steps to the completion of the MCDA

In this section, we will state all the steps a decision maker should follow to well dress a multicriteria analysis.

The following steps are necessary to conduct Multicriteria decision aid process.

STEP 1: Determine application ground of our analysis; in our case; The Moroccan financial market, (all listed shares, except the financial firms and insurance companies).

STEP 2: Define the criteria we are going to take into consideration for the analysis: in this study case we are going to use financial ratios such as, price earning ratio and risk measures such as volatility, a developed section will be stated later.

STEP 3: Rating the criteria according into a well defined scale.

STEP 4: Determine "relative weight" for each selected criterion. Taking into account the preferences of the decision makers

STEP 5: Eliminate criteria whose scores are significantly lower than others "if it's possible".

STEP 6: Calculate the relative score of each alternative. Rank all the alternatives based on their relative scores by making a comparison matrix for each criterion.

 STEP 7: Make the last ranking list of alternatives.

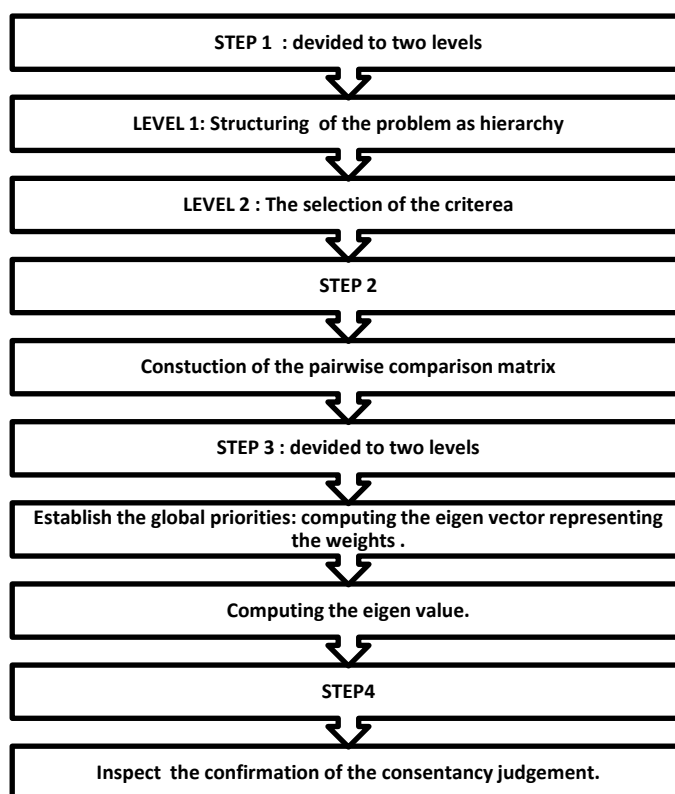Software: The software used to conduct this analysis is Excel.
AHP matrix will be filled manually from a selected data base.

2.2. AHP methodology

In order to apply the AHP method, some steps must be followed and respected.

We are going to recall these steps, as described in the original paper of (Saaty ,1990), in Figure N°1 below :

Figure N°1: Steps for AHP

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┌─────────────────────────────────────────────────────────┐
│           STEP 1 : devided to two levels                 │
└─────────────────────────────────────────────────────────┘
┌─────────────────────────────────────────────────────────┐
│     LEVEL 1: Structuring of the problem as hierarchy     │
└─────────────────────────────────────────────────────────┘
┌─────────────────────────────────────────────────────────┐
│        LEVEL 2 : The selection of the criterea           │
└─────────────────────────────────────────────────────────┘
┌─────────────────────────────────────────────────────────┐
│                        STEP 2                            │
└─────────────────────────────────────────────────────────┘
┌─────────────────────────────────────────────────────────┐
│    Constuction of the pairwise comparison matrix         │
└─────────────────────────────────────────────────────────┘
┌─────────────────────────────────────────────────────────┐
│           STEP 3 : devided to two levels                 │
└─────────────────────────────────────────────────────────┘
┌─────────────────────────────────────────────────────────┐
│ Establish the global priorities: computing the eigen     │
│ vector representing the weights .                        │
└─────────────────────────────────────────────────────────┘
┌─────────────────────────────────────────────────────────┐
│               Computing the eigen value.                 │
└─────────────────────────────────────────────────────────┘
┌─────────────────────────────────────────────────────────┐
│                        STEP4                             │
└─────────────────────────────────────────────────────────┘
┌─────────────────────────────────────────────────────────┐
│ Inspect the confirmation of the consentancy judgement.   │
└─────────────────────────────────────────────────────────┘
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Source: Saaty (1990)

Inconsistency can false the matrix, this is why we must verified the consistency of the human judgment, consistency ratio measure the coherence in the human logical judgment.

Calculation formulas:

Consistency index $CI = \frac{\lambda \max - n}{n-1}$

Consistency Ratio $CR = \frac{CI}{RI}$

Knowing that RI is the random index, generated according to a random matrix from a scale of 1 to 9 all according to (Saaty ,1994).

3. Empirical study case

3.1. The choice of criteria and alternatives

3.1.1 Alternatives

In our study case, our problem is the ranking of listed shares on the Moroccan stock exchange from the best to the worst according to the preferences of the investor. We decided to start the analysis over a period of 5 years. We will analyze the Moroccan market using sector segmentation, for each sector we will have as a result a ranking of the companies in order to show the best companies and the less interesting ones. In order to carry out a work of reference for any investor wishing to invest in the Moroccan financial market.

3.1.2 Criteria

A Fundamental analysis is imperative to assess a company's value and project its future path, in a perspective of continuity and long term investment.

The fundamental analysis relays on several disciplines such as accounting and financial analysis and it also includes stock market analysis. Merging between all these disciplines gives the investor a vision of the financial health of the company, reveals the problems the company may be suffering from and also it reveals a lot about its competition position in the stock market.

A literature review is imposed. Looking to the financial health of the firm is necessary, predicting the risk of failure of a firm has been and still a major problematic for investor. (Altman, 1968) selected 5 financial ratios to predict corporate bankruptcy, $X1$= working capital / total assets. $X2$= retained earnings / total assets. $X3$ = earnings before interest and taxes / total assets. $X4$ = market value equity / book value of total debt. $X5$ = sales / total assets. Barboza, Kimura, & Altman, (2017) confirmed in their recent research that the altman and ohlson models are still suitable , quote "*The Altman and Ohlson models are still relevant, due not only to their predictive power but also to their simple, practical, and consistent frameworks*".

After an itemized review of the literature in finance and choice of financial ratios, we decided to divide our criteria to 4 categories of ratios; these ratios must be integrated in our study case

in order to take into consideration every possible aspect that may influence the performance of the stock on the market; (Liquidity, Profitability, Debt, & Risk).

Like we mentioned earlier the fundamental stock market analysis is very important especially for arbitration between companies and determine the most competitive one. It also allows us to have a clear image about the ability of the firm to generate income and ensure continuity.

Any investor who is aware of the risk he takes when investing in the financial market knows that it's essential to take into consideration the fundamental stock market analysis. It is true that ratios are very numerous, but some of them are indispensable for a better diagnosis.

Table N°1 below shows the ratios founded while reading an extensive literature. We decided to divide it into two major categories, the first category is fundamental analysis and the second one is fundamental stock market analysis.

Table N°1: Fundamental analysis ratios

fundamental analysis	
Financial analysis	
R1	Book value per shareVC
R2	Return on equity
R3	Return on assets
R4	Working capital /total assets
R5	Leverage ratio
Stock market analysis	
R6	Dividend yield
R7	Price earnings ratio
R8	Beta
R9	Liquidity
R10	Daily Stock return

Source: Authors

- Dividend yield:

$$DY = \frac{annual\ dividends\ per\ share}{price\ per\ share}$$

This ratio indicates the percentage of gain that the company pays out each year relatively to its share price, usually using the result obtained in comparison with other years to see the progress of the percentage of distribution. Given that the Dividend yield is an index that shows the profitability of the stock, it is often used by financial analysts to compare the earnings generated by different companies.

- Price earnings ratio:

$$PER = \frac{Market\ value\ per\ share}{Earnings\ per\ share}$$

This ratio allows the decision maker to compare the price of the share on the market to its profit, in order to determine if the stock is overvalued or undervalued. Generally when the P / E ratio is high, this means that investors anticipate strong growth of the security in the future. A low P/E ratio shows us that the profit of the company is low or that it progresses slowly, as it can show us that the company is facing financial difficulties, this ratio is very useful when we compare it with different companies within the same industry sector. It should be known that the companies that do not make a profit do not have this ratio.

- Book value per share:

$$BVS = \frac{Total\ common\ stock\ holder's\ equity}{Number\ of\ common\ shares}$$

This ratio establishes a link between the equity of a company its outstanding shares, which means it attributes to each action a value. This attribution allows us to know if an action is overvalued or undervalued.

- Return on equity:

$$ROE = \frac{Net\ income}{Share\ holder's\ equity}$$

ROE reveals the return a company earns from the investment of its own shareholders. When a company experiences strong growth, it must earn a high return on equity, and an analysis of the average return on equity in recent years gives us an idea or image of the company's long-term growth.

- Return on assets:

$$ROA = \frac{Net\ profits}{Total\ assets}$$

ROA indicate how a firm is using its assets to generate earnings, in other words how this firm management is efficient in operating the assets in its disposition in order to generate earnings. This Ratio is most useful to compare companies within the same industry, because industries use assets differently. ROA is a ratio to maximize.

- Beta:

$$B = \frac{Cov\ (R_i,\ R_m)}{Var(R_m)}$$

Where:

R_i = Return of an individual stock;

R_m = Return of the overall market;

$Cov\ (R_i,\ R_m)$ = Covariance of R_i and R_m;

$Var(R_m)$ = Variance of R_m .

Beta indicates the volatility of a stock relatively to the market; it compares the movements of the stock in question with those of the market. Most financial analysts use the beta to

determine the wage of risk on an asset. It can be computed for a single stock and also can be computed for a portfolio.

- Liquidity:

$$liquidity = \frac{Total\ exchange\ stock\ per\ day}{Total\ floating\ stocks}$$

Liquidity indicates the power to buy or sell stock assets without taking a lot of time and without changing prices. One of the primary qualities of a stock, apart from its profitability and low exposure to risk is its liquidity, when a market is said to be liquid, it is easy, fast, and less expensive to invest in and carry out transactions. It is an essential condition of the stock market to guarantee investors that they will be able to sell their shares easily. Markets can sometimes be less liquid because of a strong imbalance between supply and demand. If supply goes down, prices go up. And conversely, if the asset is no longer required, the seller is obliged to make a sharp decline to find a buyer.

- Daily Stock Return:

$$R = \frac{(P_1 - P_0) + D}{P_0}$$

P_1: Close price of current day;

P_0: Close price of previous day;

D: Dividends.

It is computed based on the price change of the stock from the close of one trading day to the close of the next trading day, taking into consideration dividends distribution.
Most firms, report their financial results once markets are closed, showing the changes on their stock price, allowing investors to analyze their performance on daily basis.

- Working Capital Ratio:

$$WC\ Ratio = \frac{Working\ Capital}{Total\ Assets}$$

According to (Altman, 1968), WC Ratio is a measure of the net liquid assets of the firm relative to the total capitalization. The working capital is defined as the difference between current assets and current liabilities. Liquidity and size characteristics are explicitly considered. A high working capital to total asset ratio shows the company's ability to make payments on time. Suppliers prefer to work with such companies.

- Leverage Ratio:

$$LR = \frac{Total\ liabilities}{Total\ assets}$$

It's important to take into consideration the leverage ratio because it will allows us to measure how much capital comes in the form of debt and assesses the ability of a company to meet its financial obligations.

To be able to compute the ratios, we will proceed by extracting the variables needed for our calculations. All the data is extracted from the data source "DataStream 5.1" software.

The major question remains: which ratios are the most important for the selection of stocks? and how are we going to affect weights to each variable according to the preference of each experimented investor?

3.2. AHP application process

3.2.1. Computing the pairwise comparisons matrix

After determining the criteria of our stock selection process, we will proceed by an application of AHP to our selected data.

Since we are using AHP for the evaluation, the importance of each variable (criterion) is designated according to the scale established by (Saaty ,1990).

The pairwise comparisons matrix is calculated according to the importance of each criterion to the decision maker.

The steps of AHP are respected as mentioned in the work of (Saaty, 1987). Figure N°2 illustrates the decision process of AHP, the focus is choosing the best stock on the market; the criteria are the key to choose among the alternatives.

Figure N°2: Graphical presentation of the selection problem
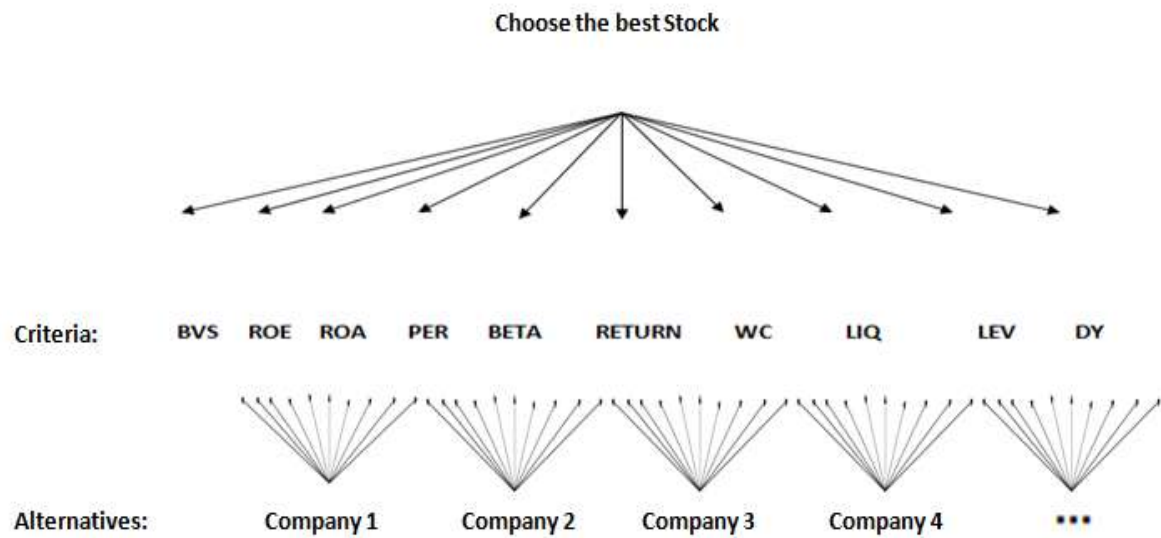
Source: Authors

We are considering the publicly traded stocks on the Moroccan market as our set of alternatives; we are not considering the financial institutions and the insurance companies due to the different process of evaluation and used ratios.

The next step consists on computing the pairwise comparisons matrix. We consider n elements criteria to compare C_1......C_n the alternatives and we note a_{ij} the relative weights of C_i up to C_j, for all $1 \leq i \leq n$ and $1 \leq j \leq n$. Then we form a square matrix $A = (a_{ij})$ of order n such that

$$a_{ij} = \frac{1}{a_{ji}} \text{ if } i \neq j$$

$$a_{ij} = 1 \text{ if } i = j$$

for all $1 \leq i \leq n$ and $1 \leq j \leq n$.

The results of this step are shown in Table N°2 below.

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Table N°2: AHP comparisons matrix

pairwise comaraison matrix	PER	EPS	BVS	ROE	ROA	LIQ	WC	LEV	RETURN	BETA
PER	1	5	5	5	5	5	5	5	0,333333333	0,333333333
EPS	0,20	1	3	3	3	0,333333333	3	0,333333333	0,333333333	0,2
BVS	0,2	0,333333333	1	3	3	0,333333333	3	0,333333333	0,2	0,2
ROE	0,2	0,333333333	0,333333333	1	0,333333333	0,333333333	3	0,333333333	0,2	0,2
ROA	0,2	0,333333333	0,333333333	3	1	0,333333333	3	0,333333333	0,2	0,2
LIQ	0,2	3	3	3	3	1	3	0,333333333	0,2	0,2
WC	0,2	0,333333333	0,333333333	0,333333333	0,333333333	0,333333333	1	0,333333333	0,2	0,2
LEV	0,2	3	3	3	3	3	3	1	0,2	0,2
RETURN	3	3	5	5	5	5	5	5	1	0,333333333
BETA	3	5	5	5	5	5	5	5	3	1
somme	8,4	21,33333333	26	31,33333333	28,66666667	20,66666667	34	18	5,866666667	**3,066666667**

Source: Authors

3.2.2. Computing eigenvalues and eigenvectors

Now, we determine the normalized eigenvector for the matrix A given by the relation:

$$A\omega = \lambda_{\max} \omega$$

Where:

ω represents the vector of criteria weights;

$\lambda_{\max}$ is the greatest eigenvalue of the matrix A.

$\lambda_{\max}$ is computed by using "the power method" described as follows:

Let A be a square matrix of order n. A non-zero vector ω is an eigenvector of A if there exists a real scalar λ such that

$$A\omega = \lambda \omega$$

The real number λ is called the eigenvalue corresponding to ω.

We suppose that the matrix A has n eigenvalues $\lambda_1, \lambda_2, ..., \lambda_n$ such that

$$|\lambda_1| > |\lambda_2| > \cdots > |\lambda_n|$$

Where $|\lambda_i|$ is the absolute value of λ_i for all $i \in \{1, ..., n\}$.

λ_1 is called the dominant eigenvalue of A and eigenvectors corresponding to λ_1 are called dominant eigenvectors of A.

We assume that the matrix A has a dominant eigenvalue with corresponding dominant eigenvectors. Then we choose an initial approximation ω_0 of one of the dominant eigenvectors of A. ω_0 must be a non-zero vector in R^n. Finally we form the sequence given by

$\omega_1 = A\,\omega_0$

$\omega_2 = A\,\omega_1 \;=\; A\,(A\omega_0) = A^2\omega_0$

$\omega_3 = A\,\omega_2 \;=\; A\,(A^2\omega_0) = A^3\omega_0$

$\vdots$

$\omega_k = A\,\omega_{k-1} \;=\; A\,(A^{k-1}\omega_0) = A^k\omega_0$

When the number of iterations k is large, we can obtain a good approximation of the dominant eigenvector of A associated with the dominant eigenvalue.

In our case A is the AHP comparisons matrix defined in Table N° 2. By application of the power method, we obtain the vector of criteria weights ω that is the dominant eigenvector of A and λ_{max} is the dominant eigenvalue λ_1 corresponding to ω.

Note that an alternative and more general method for computing the greatest eigenvalue of the matrix A and its corresponding eigenvectors consists on calculating the roots of characteristic polynomial of A i.e. the solutions of the equation $|A - \lambda I| = 0$. In this equation, $|A - \lambda I|$ denotes the determinant of the matrix $A - \lambda I$, I is the identity matrix of order n and every solution λ is an eigenvalue of A. However, when A is a large matrix, this method is impractical. But in our case, $n = 10$, then the power method is a simple iterative method that can be easily implemented.

As mentioned before, the vector ω represents the weights of the criteria, whereas λ_{max} allows us to compute consistency index "CI". This index enables the decision maker to validate the consistency of his criteria ranking.

We proceed by the calculation of the consistency ratio "CR" by dividing "CI" by the random index "RI" determined by the order of the matrix according to (Saaty, 1990).

The ratio CR must be less than 10 %, otherwise the pairwise comparisons matrix needs to be computed again because it shows the inconsistency of the human judgment.

3.3.   Practical illustration: case of the Moroccan stock market

Table N°3: Iterations of the normalized eigenvector

Normalized eigen vector	PER	EPS	BVS	ROE	ROA	LIQ	WC	LEV	RETURN	BETA
ITERATION 1	0,21190	0,06070	0,04135	0,02396	0,03123	0,06787	0,02147	0,07784	0,20345	0,26022
ITERATION 2	0,20485	0,06013	0,04207	0,0269	0,03367	0,06598	0,02348	0,07533	0,20399	0,26359
ITERATION 3	0,20535	0,06027	0,0421	0,02672	0,03354	0,06622	0,02333	0,07558	0,20373	0,26317
ITERATION 4	0,20535	0,06027	0,0421	0,02672	0,03354	0,06623	0,02333	0,07558	0,20373	0,26316

Source: Authors

Table N°4: λ_{max} , CI and CR

λ_{max}	11,11410679
CI	0,123789643
CR	8,308 %

Source: Authors

After building the pairwise comparisons matrix, we have proceeded to the calculation of the eigenvector and the eigenvalue which required four iterations as shown in Table N°3. Then we have validated our study by the computation of the consistency index and the consistency ratio. The values of λ_{max}, CI and CR are shown in Table N°4. These results prove that the consistency ratio is 8.30%, which makes it in the accepted limits of the inconsistency.

Table N°5: Criteria priorities

Criterion	Priority
PER	20,54%
EPS	6,03%
BVS	4,21%
ROE	2,67%
ROA	3,35%
LIQ	6,62%
WC	2,33%
LEV	7,56%
RETURN	20,37%
BETA	26,32%
Sum	100%

Source: Authors

Table N°5 above is derived from the results found in Table N°3 and represents the weights of the criteria given by the final normalized eigenvector. These weights are expressed as percentage in order to show the priority of each criterion in relation to the others. So we find that the beta is the most important criterion for the decision maker with 26.32 % of the total weight, followed by PER (Price Earnings Ratio) with 20,54 % and RETURN (Daily Stock Return) with 20,37 %. We notice that the risk and the return ratios are the most significant to the decision maker.

Table N°6: Scoring system and data entry: Scoring the criteria.

Critaria	Score computation
Beta	If beta <0: 0 , If beta >=min : beta/(1-min), If beta >1:0
Liquidité	If L=< min : 0 , If L>min: L/(max-min)
RETURN	If R<min:0 , If R>= min : R/(max-min)
ROE	If ROE < min : 0 , If ROE>=min: ROE/(max-min)
BPA	If BPA<min: 0, If BPA>=min : BPA/(max-min)
P/E RATIO	If PER<=0 :0, If PER<min: 1, PER>=min:PER/(max-min)+1
BVS	If BVS > Share price : 1 , If BVS = < Share price: 0
ROA	If ROA < min: 0, If ROA>= min: ROA/(max-min)
WC	If WC < min: 0, If WC >= min: WC/(max-min)
LEV	If LEV < min:1 , If LEV> min: LEV/(max-min)
min	minimum required
max	maximum limit

Source: Authors

As shown in Table N°6, the minimum required is a lower bound determined by the investor (generally the mean of all obtained results) and the maximum is the upper bound, also determined by the investor, as a limit to not exceed.

4. Results and discussion

4.1. Overall scoring of Moroccan companies

Using the previous scoring system, we calculated the scores for all ratios mentioned before, and then we computed the final score using the AHP weights.

We applied this methodology on the data extracted from DataStream software covering the period of 2013 to 2016. As a first step, we have calculated the scores for all Moroccan companies, regardless of their sector of activity. Then we applied a sector segmentation in order to sort companies within the same sector and choose among them the most performing ones.

The final score would allow investors to remove some companies from their choices and narrow their search to those who are in the top of the ranking.

Table N°7 bellow presents the final ranking of scores applied to the Moroccan companies in all sectors. Each criterion is assigned with its corresponding AHP weight (given in Table N°5) and the summation of the weights is 100%. So the stock with the highest overall score is

regarded as the most attractive stock. For example, DARI COUSPATE is at the top of the ranking with score of 1,286025 and then would be the best choice for investors, while MED PAPER SA has the worst and negative score (-0,351831) meaning that it could be a very risky alternative for investment.

Table N°7: AHP scores final ranking applied to Moroccan companies

Criteria	PER	EPS	BVS	ROE	ROA	LIQUIDITY	WC	LEVERAGE	RETURN	BETA	SCORE
Ponderation AHP weights	21%	6%	4%	3%	3%	7%	2%	8%	20%	26%	100,00%
Alternatives											
DARI COUSPATE	2,24468454	1,262289	1	1,2622888	1,32334058	2,148154962	2,245	1	1,76012498	0	1,286025
IMITER STE METALLUR	2,57958591	2,150032	1	2,1500317	1,87866093	1	2,58	1	1,07793723	0,003541	1,244367
HIGHTECH PAYMENT	2,22161105	1	1	1	1,25298474	1	2,222	1	1,78827052	0	1,18527
COMPAGNIE MINIERE	2,23045766	1,900122	1	1,90012199	2,19064229	1	2,23	1	1,19499865	0,0041388	1,17726
PROMOPHARM	2,50674347	1,18941	1	1,18941005	1,35625915	1	2,507	1	1,12883718	5,849E-05	1,136083
INVOLYS SA	2,45065249	1	1	1	1,3124115	1	2,451	1	1,11396775	0,0018715	1,102757
AUTO HALL	1,98010053	1	1	1	1,23244804	1	1,98	1	1,54843293	0	1,080491
COLORADO STE DES ETS	2,0679303	1	1	1	1,27669508	1	2,068	1	1,39504506	0	1,070811
ALUMINIUM DU MAROC	1,74395899	1,375535	1	1,37553498	1,20551775	1,834499271	1,744	1	1,10728554	0,0026827	1,024351
DISWAY SA	1,96857505	1	1	1	1	1	1,969	1	1,17628756	0	0,994243
CARTIER SAADA SA	1,83468431	1	1	1	1	1	1,835	1	1,09981687	0	0,948046
SOCIETE DE REAL	2,30351052	1	1	1	1	2,069981837	2,304	1	0	0	0,902052
MICRODATA	2,20045856	1	1	1	1,53958164	1	2,2	-1,328699783	1,18780527	0	0,891698
STOKVIS NORD AFRIQUE	2,11226941	1	1	1	1	1	2,112	-1,614730601	1,43158037	0	0,881479
AUTO NEJMA	2,20125756	1,339786	1	1,33978643	1,36334399	1,26136329	2,201	1	0	0	0,86686
DELTA HOLDING SA	1,88165829	1	1	1	1	1	1,882	-1,28589947	1,08010754	0,0029203	0,782762
LAFARGEHOLCIM MAROC	1	1,297038	0	1,29703757	1,53551814	1	1	1	1,18940797	0,0183844	0,781964
CIMENTS DU MAROC	1	1,208085	0	1,20808547	1,35656206	1	1	1	1,23641829	0,0056248	0,774444
SOCIETE MAGH	1,73720747	1	1	1	1,21152866	1	1,737	-1,435173991	1,17088398	0	0,763266
M2M GROUP	2,0059719	1	1	1	1	1	2,006	1	0	0	0,763151
NEXANS MAROC	1,94963808	1	1	1	1	1	1,95	1	0	0	0,750269
SOCIETE DE THER	1	1,2422	0	1,24220015	1,36801364	1	1	1	1	1	0,72815
REBAB COMPANY SA LIM	1,72332515	1	1	1	1	1	1,723	1	0	0	0,698517
COMPAGNIE SUCRER	1	1,557104	0	1,55710353	1,23926653	1	1	-1,368819876	1,38767485	0	0,651158
DOUJA PROM ADDOHA	2,36575981	1	1	1	1	1	2,366	-1,593499339	0	0	0,649397
ALLIANCES DEV	2,33635245	1,178115	1	1,17811458	1	1	2,336	-1,800312787	0	0	0,642534
ZELLIDJA SA	1,94184191	0	1	0	0	1	1,942	1	0	0	0,627963
CTM S.A	1	1	0	1	1	1	1	-1,356267123	1,35872909	0,0005427	0,589868
LES EAUX MINERAL	1	1	0	1	1,20929883	1	1	-1,369558232	1,24898076	0	0,573381
AFRIQUIA GAZ	1	1,431302	0	1,43130157	1	1	1	-1,716419882	1,09100132	0	0,545476
LESIEUR CRISTAL	1	1	0	1	1	1	1	-1,254458167	1,05508493	0	0,524337
UNIMER GROUPE	1	1	0	1	1	1	1	-1,614689645	1,05508493	0	0,508331
STE NATIONALE	1	1	0	1	1	1	1	1	0	0,0143014	0,494774
MAROC DELATTRE	1	1	0	1	1	1	1	-2,012134538	1	0	0,467068
FENIE BROSSETTE	1,75320094	0	1	0	0	1	1,753	-1,356790767	0	0	0,406688
TIMAR S.A.	1	1	0	1	1	1,935914647	1	-1,331698899	0	0	0,376751
MAGHREB OXYGEN	1	1	0	1	1	1	1	-1,346690944	0	0	0,313637
IB MAROC	1	1	0	1	1	1,310078016	1	-1,756376607	0	0,0024371	0,303847
STE DE TRAVAUX DE	1	1	0	1	1	1	1	-2,242416597	0	0	0,245933
AGMA LAHLOU TAZI	-1	1,918194	0	1,9181942	1,52339912	1,758699432	-1	-1,622819254	1,21347534	0,0015327	0,230703
RISMA SA	-1	0	0	0	0	1	-1	-1,79851158	2,04196011	0	0,117615
LYDEC	-1	1	0	1	1	1	-1	-2,104818166	1,42670846	0	0,089641
CENTRALE DANONE	-1	1	0	1	1	1	-1	-1,523666573	1,09074523	0	0,065122
MANAGEM SA	-1	1,164143	0	1,16414313	1	1	-1	1	0	0,0109713	0,050822
ITISSALAT AL MAGHRIB	-1	1	0	1	1,38450326	1	-1	-1,355349598	0	0,0094132	-0,129
NATIONALE D'ELECTROL	-1	0	0	0	0	1	-1	-1,442038505	0	0	-0,271448
MAROCAINE DE	-1	0	0	0	0	1	-1	-2,015718896	0	0,0088771	-0,312473
MED PAPER SA	-1	0	0	0	0	1	-1	-2,031589805	0	0,0006752	-0,315831

Source: Authors

4.2. Scoring of Moroccan companies by sector

As mentioned before, we have established a sector ranking of Moroccan companies which is based on the scores given in Table N°7. The results obtained are presented in the following tables.

Table N°8: Sector scores - Materials, Software and Computer Services

Matériels, Logiciels et services informatiques	
Alternatives	**Score**
HIGHTECH PAYMENT	1,185270021
INVOLYS SA	1,102757154
DISWAY SA	0,994243385
MICRODATA	0,891698045
SOCIETE MAGH	0,763265834
M2M GROUP	0,763151414
IB MAROC	0,303847012

Source: Authors

From Table N°8 we observe, for example, that HIGHTECH PAYEMENT is in the first place of ranking with the highest score of 1.1852 followed by INVOLYS SA with 1.1027. So we can easily conclude that those two companies are the most attractive for investment in the sector of materials, software and computer services. Whereas, IB MAROC is in the end of the classification with a score of 0.3038, and then it would be less attractive.

Table N°9: Sector scores – Agribusiness and production

Agribusiness and production	
Alternatives	**Score**
DARI COUSPATE	1,286024686
CARTIER SAADA SA	0,948046333
COMPAGNIE SUCRER	0,651157797
LESIEUR CRISTAL	0,524336856
UNIMER GROUPE	0,508331198
CENTRALE DANONE	0,065121776

Source: Authors

A similar analysis applied to the sector of agribusiness and production (Table N°9) shows that DARI COUSPATE is the most attractive investment with a score of 1.286, while CENTRALE DANONE is at the bottom of the ranking with a score of 0.065, which is a very bad score, and then would be the last choice for the investors.

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In our analysis of Moroccan market, we noted cases where a sector includes only one or two companies, such as the industrial chemistry sector and the telecommunications sector (Tables N°9 and N°10). So in this particular situation, it would be better to eliminate this sector from consideration, or to compare it to a similar one.

Table N°9: Sector scores – Industrial chemistry

industrial chemistry	
Alternatives	**Score**
MAGHREB OXYGEN	0,31363655
NATIONALE D'ELECTROL	-0,27144775

Source: Authors

Table N°10: Sector scores – Telecommunications

Telecommunications	
Alternatives	**Score**
ITISSALAT AL MAGHRIB	-0,12899991

Source: Authors

Finally, as shown in Table N°11, we have compared the results covering the four consecutive years from 2013 to 2016, by taking agribusiness and production sector as an example. This comparison study aims to assess any changes in the performance of the companies representing this sector.

We notice that DARI COUSPATE is always at the top of the ranking with the highest score throughout the period 2013-2016. We can also see, for example, that CENTRALE DANONE moved up three places in the ranking from 2013 to 2014, and then occupied the last place again from 2015 to 2016.

This kind of comparison would allow the investor to know when to sell a share and when to start considering buying it.

Table N°11: Agribusiness and production sector scores comparison – 2013 to 2016

Agribusiness and production							
2013		**2014**		**2015**		**2016**	
Dari couspate	1.286024	**Dari couspate**	0.918827	**Dari couspate**	1.071894	**Dari couspate**	1.071894
Cartier Saada SA	0.948046	**Cartier Saada SA**	0.710420	**Cartier Saada SA**	0.790415	**Cartier Saada SA**	0.790415
Compagnie Sucrer	0.651157	**Compagnie Sucrer**	0.646327	**Compagnie Sucrer**	0.769261	**Compagnie Sucrer**	0.769261
Lesieur Cristal	0.523368	**Lesieur Cristal**	0.557237	**Lesieur Cristal**	0.723469	**Lesieur Cristal**	0.723469
Unimer Groupe	0.508331	**Unimer Groupe**	0.503708	**Unimer Groupe**	0.694737	**Unimer Groupe**	0.694739
Centrale Danone	0.065121	**Centrale Danone**	0.399269	**Centrale Danone**	0.328662	**Centrale Danone**	0.328666

Source: Authors

Conclusion

The AHP method is a very effective process to help investors personalize their tool of share picking, by taking into consideration their personal judgment and criteria.

The sector segmentation makes it easier to the investor to apply the diversification rule to his portfolio, by simply picking the firm with the highest score in each sector.

This process is only effective for the shares picking and not for the portfolio optimization. After choosing the stocks from the final ranking, investors have to determine the amounts of money to invest in each company.

BIBLIOGRAPHIE

Altman, e. I. (1968). The prediction of corporate bankruptcy: a discriminant analysis. *The journal of finance*, *23*(1), 193–194.

Barboza, f. kimura, h. & altman, e. (2017). Machine learning models and bankruptcy prediction. *Expert systems with applications*, *83*, 405–417.

Benjana, h. (2019). Portfolio manager : un metier en perpetuel mouvement (cas du maroc) portfolio manager : a job with a perpetual movement. Revue du Contrôle de la Comptabilité et de l'Audit. *4*, 611–626.

Bouri, & al.(2002). A multi-criterion approach for selecting attractive portfolio. Journal of Multi-Criteria Decision Analysis.

Eugène fama (1965). The behavior of stock-market prices. The journal of business, vol. 38, no. 1 (jan., 1965), pp. 34-105.

Ekeland,(1993). Finance: Un nouveau domaine des mathematiques appliquees. Revue Francaise de Gestion, 44–48 .

Kazimieras zavadskas edmindas, t. Z. (2011). Multiple criteria decision making (mcdm) methods in economics: an overview. Technological and economic development of economy , 17(2), 397–427.

Markowitz, H.M. (1952) Portfolio Selection. Journal of finance, 7(1), 77–91.

Roy, b., & vanderpooten, d. (1996). The european school of mcda: emergence, basic features and current works. *Journal of multi-criteria decision analysis*, *5*(1), 22–38.

Saaty, r. W. (1987). The analytic hierarchy process-what it is and how it is used. *Mathematical modelling*, *9*(3–5), 161–176.

 saaty, t. L. (1990). How to make a decision: the analytic hierarchy process. *European journal of operational research*, *48*(1), 9–26.

Saaty, t. L. (1994). How to make a decision : the analytic hierarchy process. European Journal of Operational Research. 48*24*(6), 19–43.

Samya. Tahir, a. K. (2019). Revue d'etudes en management et finance d'organisation. *Revue d'etudes en management et finance d'organisation*, *9*, 1–18.

Steuer, r. E., & na, p. (2003). Multiple criteria decision making combined with finance : a categorized bibliographic study. European Journal of Operational Research *150*, 496–515.

 zopounidis, c. (1999). Multicriteria decision aid in financial management. European Journal of Operational Research .*119*, 404–415.