IRMBR
www.irmbrjournal.com December 2014
International Review of Management and Business Research Vol. 3 Issue.4

Construction of a Multicriteria Model for the Assessment of U.S. Stocks

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Abstract

According to the conventional theory, portfolio management models are exclusively based on the twain criteria of expected return and risk, with the latter being generally measured by the variance. Nonetheless, such models have been shown to be fraught with anomalies. Hence, we propose in this paper an original methodology for the assessment of stock market shares using multicriteria decision methods. We consider an exhaustive set of criteria accredited in the financial literature and used by the professional of portfolio management to boot. The ranking of financial securities as well as their sorting out into three different categories involving attractive shares (to buy), uncertain shares (to keep) and non-attractive shares (for sale) are both a common practice for portfolio managers. This paper focuses on the application of multicriteria decision aid for the ranking and sorting out of 194 shares listed on the U.S. market.

Key Words: *Portfolio Management, Multicriteria Decision Aid, ranking, sorting out, MINORA and ELECTRE TRI.*

Introduction

The traditional approach to portfolio management, through its various models, has been shown to be fraught with various anomalies. Indeed, the "mean-variance model" of Markowitz (1952) and the “expected utility theory” of Von Neumann et Morgenstern (1947) have some limitations with respect to the plausibility of their axioms, such as the approximation of the "real" utility function of the investor (especially those institutional investors) by the quadratic utility function or the hypothesis on the distribution of returns. The term "mean-variance model" also may suggest a bi-criteria problem, whereas in the theory of expected utility, the risk is amenable to the uncertainty affecting the determination of expected return, which is expressed in the form of the utility function, so that the variance plays no role, and risk is no longer considered as a criterion in its own right but as a component of the unique criterion of the expected return.

According to the Capital Asset Pricing Model introduced by Sharpe (1964), Lintner (1965) and Mossin (1966), the only salient influence is the markets (with the diversification principle). But minimizing the beta is not necessarily a good means to hedge against the risk and may deplete opportunities for gain instead. As for the Arbitrage Pricing Theory (Ross, 1976), even though it uses many influences, it remains an empirical model. Thus, the inability of traditional and theoretical models to reflect the multidimensional nature of the portfolio management problem is due to the inherent conception of risk which is reduced to its probabilistic dimension. It does not encompass the various sources of influences that affect performance and confer to the risk its multidimensional character.

The main advantage of using methods of multicriteria decision is to synthesize in a single procedure the practical and theoretical aspects of portfolio management. Using multiple criteria decision also facilitates and promotes the analysis of achievable compromise between different and conflicting criteria used in portfolio management. It can also manage as well as help to clarify the heterogeneity of the scales and their fuzzy and imprecise assessments.

Another advantage of the multicriteria decision procedures is their ability to adapt to the particular preferences of the investor. They thus help to integrate in a non-normative way the investor's behavior towards risk in the portfolio management.

It should be noted that we have often sought to justify the development of multicriteria decision aid, stressing that "reality" itself is multicriteria in nature and often involves the consideration of several points of view. But according to Bouyssou (1993), "Multicriterion paradigm" for the decision aid is "to believe that constructing explicitly several criteria can have a positive impact on the modeling process." So, in addition to the argument concerning "reality" and its many facets, there is an "Act of faith" or a conviction to address the problem according to the multicriteria approach.

Portfolio managers need a useful model for their consulting business such as the storage of financial securities as well as their sorting out into predefined categories. This paper deals with the construction of a multicriteria model for the assessment of american stock market shares. A brief review of the literature is presented in section 2. Section 3 deals with the general methodological framework. In section 4, the application of MINORA for ranking shares is presented. The use of ELECTRE TRI for sorting shares and the sensitivity analysis are displayed in section 5. We end with a conclusion.

In portfolio management, the application of multicriteria decision aid solves two sorts of problems: the multiattribute problems (share assessment) and the multiobjective problems (determination of weights for a portfolio). Based on the apposite literature, and especially the seminal work of Hurson and Zopounidis (1997), table 1 offers a synopsis of studies that have examined the multicriteria methods for portfolio management (see table 1).

Table 1: Multicriteria methods for portfolio management

Study	Problem	Method	Criteria	Comments
Saaty, Rogers and Pell (1980)	share evaluation and portfolio selection	« Analytical Hierarchy Process »	Extrinsic factors, intrinsic factors and investor objectives	The AHP part of an approach is purely descriptive. There is a significant effort to identify and use all the influencing factors affecting the shares value.
Lee and Chesser (1980)	portfolio selection	« goal programming »	Expected return and beta and principles of diversity	The multidimensional nature of risk is not exploited.
Evrard and Zisswiller (1983)	share evaluation	the theory of multi-attribute utility	Expected return, risk, PER and earnings per share	The study was conducted on phantom stocks then on real ones, which allows seeing investor' behavior and his intuition in front of a real risk.
Martel, Khoury and Bergeron (1988)	portfolio selection and filing arrangement	ELECTRE I and II	Average monthly return, logarithmic variance, PER and capitalized value of the firm	The outranking approach does not address the problem of portfolio construction; it should be reserved for the evaluation of shares or portfolios already established.

Colson and De Bruyn (1989)	share evaluation and portfolio selection	« goal programming »	gain level, portfolio risk, dividends or interest and diversification	This is one of the few studies that propose a complete decision support system for portfolio management.
Szala (1990)	share evaluation	ELECTRE III and PREFCALC	Earnings growth, sales growth, net margin, ROE, the PER, ongoing cash flow, float, financial expenses to sales, gross operating income, long term liabilities to sales and long term Liabilities/cash flow	The author has provided a remarkable effort to use all the criteria of interest in portfolio management. However, a large number of criteria can be a disadvantage by making it difficult multicriteria analysis.
Khoury, Martel and Veilleux (1993)	the selection of international portfolios	ELECTRE Is and ELECTRE III	Expected return, standard deviation, transaction cost, risk - country and currency risk	This is one of the few studies to look at international portfolios and to emphasize the multidimensional nature of international risk.
Martel, Azondékon and Sédzro (1998)	ranking of share for portfolio construction	MAZ	Total return, dividend yield and the PER ratio	The approach is distinguished by its flexibility and its ability to verify the stability of the stored assets.
Xella-Ricci and Hurson (1998)	share evaluation	ELECTRE TRI and MINORA	Criteria for the Arbitrage Pricing Theory such as monthly and annual growth in industrial production, unexpected inflation, changes in the bond risk premium, change in the structure of interest rates, changes in the trade balance, the market return (CAC 240)	The originality of the study is to use the criteria revealed by the Arbitrage Pricing Theory. The authors suggest the adoption of accounting criteria and financial criteria thus allowing a better assessment of stock performance.
Ogryczak (2000)	portfolio selection	« multicriteria linear programming model »	Mean and various risk averse preferences	This study helps to identify solutions of the portfolio selection problem which are optimal with respect to risk averse preferences.
Bouri, Martel and Chabchoub (2002)	portfolio selection	PROMETHEE II and ELECTRE III	Expected return, βm market, liquidity and solvency	To accept the model (Mean, Variance), we need information on other criteria to be included in the price of the shares.
Pendaraki, Zopounidis and Doumpos (2005)	assessment and composition of mutual funds	UTADIS and « goal programming »	Expected return, market βm, and size of the firm	This is one of the few studies dedicated to evaluating mutual funds.
B.Abdelaziz, Aouni and El Fayedh (2007)	portfolio selection	the « chance constrained compromise programming model »	Expected return, risk and liquidity.	The methods were applied to portfolios of shares listed on the Tunis Stock Exchange (BVMT)
Li, Qin and Kar (2010)	portfolio selection	« genetic algorithm » and « Fuzzy simulation »	Mean, variance and skewness of returns	In this paper, a concept of skewness for fuzzy variable was proposed, and several useful theorems were proved.

Dastkhan, Gharneh, and Golmakani (2011)	portfolio selection	« Fuzzy mathematical programming » and « hybrid genetic algorithm »	Expected return and risk	The results show the high performance of fuzzy portfolios based on 75 assets of New York stock exchange (NYSE) comparing with the performance of crisp portfolios and S&P 500 index.
Xidonas, Mavrotas, Zopounidis and Psarras (2011)	selection and composition of portfolios	«multiobjective mathematical programming »	Return, dividend yield, mean absolute deviation and beta coefficient	The originality of the study is to present an integrated approach for the construction of equity portfolios, which take into account the inherent multidimensional preferences of the decision maker.
Ho and Sherris (2012)	portfolio selection	AHP and ELECTRE III	Expected loss and excess return relative to the risk-free rate	The originality of this study lies in the selection of portfolio exclusively related to insurance activity.
Pérez-Gladis, Rodríguez, M'zali, and Lang (2013)	selection and composition of portfolios	DEA and SSD	Financial and nonfinancial Performance	This study compares the performance of conventional versus socially responsible mutual funds on an empirical data set.

Methodological Framework

The analysis of different families of multicriteria decision aid methods, viz. Multi-Attribute Utility Theory, the outranking approach and the interactive approach, reveals that each family of methods has advantages and drawbacks. However, methods based on a constructive approach, such as the outranking methods and some interactive methods, seem to outstrip multicriteria methods, the latter being more adapted to solving practical problem than descriptive methods (theory of Utility Function and other interactive methods) especially when decision maker's preferences are not stable, unstructured and conflictual. That's why we choose MINORA system and ELECTRE TRI method to tackle our research question.

MINORA has been the subject of numerous applications in various fields such as marketing, research and development, environmental management, country risk, and especially financial management and portfolio management (Zopounidis, 1993 and Hurson and Ricci-Xella, 1998). ELECTRE TRI has been applied in financial management for crediting problems (Bergeron, and Twarabimenye Martel, 1994), failure risk (Dimitri and al. 1995, Zopounidis and al. 1995) and portfolio management (Hurson and Xella Ricci, 1998).

Even if MINORA and ELECTRE TRI are not financial methods for stock assessment, they present several advantages for portfolio management which will emerge hereafter.

Presentation of the MINORA Method

The "Interactive Multicriteria Ordinal Regression Analysis" system or MINORA was introduced by Siskos et al. (1993) and Spiridacos and Yannacopoulos (1994). The objective of MINORA is to rank the shares from the "best" to the "worst".

Indeed, there are other methods that use multicriteria decision aid for the problem of ranking. While the ELECTRE III method (Roy, 1978) is, from a theoretical point of view, arguably the most complete, it entails a great deal of complexity daunting most decision makers, thereby deterring from a widespread use thereof. This drawback partly lies behind PROMETHEE methods (Brans and al., 1984, Brans and Vincke, 1985). The decision maker will choose, for each criterion, one of six forms reflecting how his preferences evolve.

MINORA system has several advantages. First, it addresses a common concern of portfolio managers in the consulting activities of their agents which is the ranking of financial assets. Then, it is an interactive and constructive help to the investor seeking to build its own model of preferences. In addition, it organizes into a single procedure all the activity of multiple criteria decision ranging from formulating the problem to getting a result. Finally, thanks to the interactivity of MINORA, the investor is fully involved in the decision process and is assisted by a powerful graphics system. Thanks to the interactive use of the UTA algorithm (Jacquet-Lagrèze and Siskos, 1982), MINORA system can solve the problems of multicriteria ranking on a set of alternatives A. Indeed, the algorithm UTA has built a utility function from a preorder defined by the user on a subset A' called "Reference Alternatives". The procedure, based on a principle of ordinal regression, consists of solving a small linear program. The algorithm UTA offers marginal utility functions piecewise linear as compatible as possible with the preorder given by the user. The latter can interactively change the marginal utility functions within the limits provided by a sensitivity analysis of the problem of ordinal regression. To make these changes, the user is assisted by a very appealing graphical interface. The utility function accepted by the user is extrapolated over all alternatives and results in a complete preorder on the set of alternatives A. The assumption underpinning MINORA is the existence of an additive separable utility function that is the sum of k partial utility functions of the form:

$$U(G(a)) = \sum_{i=1}^{k} u_i(g_i(a))$$, k being the number of criteria.

The originality of MINORA compared to the traditional approach of the Utility Function stems from its making a disaggregation instead of an aggregation of preferences. Indeed, the traditional approach assumes that the utility function is known and follows a preorder; hence its denomination of preference aggregation procedure. In contrast, in MINORA, the utility function is unknown, and is only assumed to have the separable additive form, so that the problem is to estimate a utility function to be possibly the least distant from the initial preorder issued by the decision maker. It follows, therefore, the opposite of the classical approach.

To estimate the utility function, we ask the decision maker to rank a certain number of alternatives in order of preference. The estimation of the utility function then takes place by solving the following linear program: $MinF = \sum_{a \in A} (\sigma_a^+ + \sigma_a^-)$ under the following constraints:

$$\begin{cases}
\sum_{i=1}^{k} \left[u_i(g_i(a)) - u_i(g_i(b)) \right] + \sigma_a^+ - \sigma_a^- - \sigma_b^+ + \sigma_b^- \geq d, \forall (a,b) \in A \times A / a \succ b & (1) \\
\sum_{i=1}^{k} \left[u_i(g_i(a)) - u_i(g_i(b)) \right] + \sigma_a^+ - \sigma_a^- - \sigma_b^+ + \sigma_b^- = 0, \forall (a,b) \in A \times A / a \approx b & (2) \\
u_i(g_i(g_{i,h})) - u_i(g_i(g_{i,h+1})) \leq 0, \forall h = 0,....\eta_i, \forall i = 1.......k & (3) \\
u_i(g_{i*}) = 0, \sum_{i=1}^{k} u_i(g_{i*}) = 1, \forall i = 1.......k & (4) \\
u_i(g_i(g_{i,h})) \geq 0, \sigma_a^+ \geq 0, \sigma_a^- \geq 0, \forall h = 0,....\eta_i, \forall i = 1.......k, \forall a \in A & (5)
\end{cases}$$

This linear program is used to estimate the values $u_i(g_i)$ so that the approximation of the resulting utility function maximally complies with the order established by the investor. Variables σ_a^+ and σ_a^- are slack variables: they represent potential errors related to the utility afforded for share a.

To evaluate the optimality of the estimated utility function, that is, the closeness of the pre-established order by the decision maker and the one provided by the model, we use the notion of Kendall distance to estimate the Kendall coefficient of correlation or Kendall τ: $\tau_k(A, A')$

$$\tau_k(A, A') = 1 - 2\frac{d_k(A, A')}{d_k^*}$$

Where $d_k(A, A')$ is the distance between the two preorders Kendall A and A 'and its maximum. If the two preorders are identical, the Kendall distance is zero.

Presentation of the ELECTRE TRI Method

The methods belonging to the family ELECTRE (**EL**imination **E**t **C**hoix **T**raduisant la **RE**alité) have acquired a great reputation and have been applied to a number of multicriteria decision problems. ELECTRE TRI method was developed by Yu in 1992. This is one of the few methods able to resolve the sorting problem.

Starting from a finite set of alternatives evaluated on quantitative and / or qualitative criteria and a set of categories for predefined recommendations (eg, very good, average, very bad) ELECTRE TRI provides users with two different procedures (pessimistic and optimistic) that can affect all the alternatives into these predefined categories.

The advantages of the ELECTRE TRI approach are the following. First, it accommodates incomparability and intransitivity in the investor preferences and will not allow total compensation between alternative performances according to different criteria. Then it can call attention to alternatives which exhibit states of incomparability and whose assignment is ambiguous. Finally, the technique used in ELECTRE TRI presents little difficulty and will be easily understood by the decision maker.

Assigning an alternative into a category is based on comparing the alternative to reference profiles with the outranking relation. The different categories are defined by reference profiles, denoted r_j, and called the value vectors of the criteria. The reference profiles are phantom alternatives representing well-defined standards by the decision maker and to whom the alternatives will be compared and distributed among the different categories. Each category is limited by a high-profile and low profile.

In ELECTRE TRI, an outranking relation is calculated between each alternative and each profile r, in concordance, discordance, thresholds of indifference, preference and veto. Initially, a partial concordance index is calculated for each criterion and each pair (alternative, profile). The partial concordance index for aSr_j according to the criterion i is given by the following formula:

$$c_i(a, r_j) = \begin{cases} 1 \quad \text{si } g_i(a) \succ g_i(r_i) - q_i(g_i(r_j)) \\ \dfrac{p_i(g_i(r_j)) - (g_i(r_j) - g_i(a))}{p_i(g_i(r_j)) - q_i(g_i(r_j))} \text{ si } g_i(r_j) - q_i(g_i(r_j)) \geq g_i(a) \succ (g_i(r_j) - p_i(g_i(r_j)) \\ 0 \quad \text{sis } g_i(a) \leq g_i(r_j) - p_i(g_i(r_j)) \end{cases}$$

Where $p_i(g_i(r_j))$ and $q_i(g_i(r_j))$ are the preference and indifference thresholds to the criterion i when the value of the latter is equal to the evaluation of a on this criterion.

The average of the partial concordance indices weighted by the weight of the criteria can then assess global concordance $C(a,r_j)$, for the relationship aS r_j

$$C(a,r_j)=\frac{\sum_{j=1}^{k}\lambda_i c_i(a,r_j)}{\sum_{j=1}^{k}\lambda_i}$$

Similarly, in ELECTRE TRI, the discordance on a criterion can be formalized as a partial discordance index. The partial discordance index of the criterion i for aSrj i is given by the following formula:

$$d_i(a,r_i)=\begin{cases}1 & \text{si } g_i(a)\le g_i(r_j)-v_i(g_i(r_j))\\ \frac{(g_i(r_j)-g_i(a))-p_i(g_i(r_j))}{v_i(g_i(r_j))-p_i(g_i(r_j))} & si\ g_i(r_j)-v_i(g_i(r_j))\prec g_i(a)\le(g_i(r_j)-p_i(g_i(r_j))\\ 0 & \text{si } g_i(a)\succ g_i(r_j)-p_i(g_i(r_j))\end{cases}$$

Where $v_i(g_i(r_j))$ is the veto threshold of criterion i when the value of this criterion is equal to the r_j assessment. The degree of credibility of the relationship a outperforms r_j, $\sigma_s(a, r_j)$ is calculated as follows:

$$\sigma_s(a, r_j) = \begin{cases}C(a,r_j) & \text{si } \overline{G}=\varnothing\\ \prod_{i\in \overline{G}}\frac{1-d_i(a,r_j)}{1-C(a,r_j)} & \text{si } \overline{G}\neq\varnothing\end{cases}$$

Where G is the set of criteria such that $\overline{G}(a,r_j)$ = {iєG / $d_i(a,r_j)\succ C(a,r_j)$ }

The value of the credibility index is the value of the global concordance index penalized by discordance indices when they are higher than the global concordance index. Concretely, in ELECTRE TRI, the valued outranking relation is transformed into a net outranking relation from an outranking threshold called "cutting level" λ.

A outperforms r_j if and only if the outranking degree of credibility r_j by a is greater than λ, that is to say:

$aSr_j \Leftrightarrow \sigma_s(a, r_j) \geq \lambda$, with $0.5 \leq \lambda \leq 1$

The value of λ, as well as the threshold values of concordance and discordance in ELECTRE, can be interpreted as the decision maker attitude towards the risk. Thus the more the cutting level λ is high the more the decision maker is risk averse.

In ELECTRE TRI, the two assignment procedures (optimistic or pessimistic) differ in their behavior towards certain alternatives which are incomparable to reference profile. Incomparability appears when it is not possible to make judgments without judging equivalent alternatives and reference profile. ELECTRE TRI optimistic will then favour the alternatives that have excellent evaluation criteria, even if the evaluation on other criteria is poor. However, ELECTRE TRI pessimistic does only affect in the "good" categories alternatives whose quality is well established, rejecting those that may constitute a problem in the "bad" categories. However, the best use of ELECTRE TRI is to apply the twain assignment procedures at the same time and compare their results.

Ranking of Shares by the MINORA Method

Criteria Formulation

As noted by Martel and al. (1988), "measuring risk and return on probabilistic context does not always comply with the investor' perception of these two keys concepts". That is why several researchers try to introduce additional goals in portfolio management. So a good assessment of the shares must integrate all factors which are considered relevant from the classical theoretical approach, fundamental analysis, etc. These criteria can be classified into three categories: financial criteria, stock criteria and qualitative criteria. To identify the relevant criteria, we explored the literature and then simulated the behavior of the investor. In multicriteria decision aid, it is important that the criteria used be not correlated to avoid the problem of redundancy that could affect the final result (called dictator criteria). We check the independence of the criteria using the correlation matrix[1].

Table 2: Relevant criteria for portfolio management

	Criterion	*Criterion measurement*
Financial criteria	Economic return or Return On Assets (ROA)	Ratio of operating income after tax on economic assets
	Liquidity Ratio or Current Ratio	Ratio of current assets on operating liabilities
	Leverage ratio (long term)	Ratio of long term liabilities to total assets
Stock criteria	Return	Average return over 60 months
	Bêta	5-year historical beta
	Price to Earning Ratio	Ratio between the price Earnings per share
	Market to Book	Ratio of the market value over book value of the share
	Dividend	Annual dividend per share
	Marketability (depth)	Report of the transaction volume on the number of issued shares
Qualitative criteria	Corporate governance index	Annual average of corporate governance index

Table 3: The correlation matrix

	REND	**BETA**	**PER**	**MTB**	**DIV**	**MARK**	**CURRAT**	**SOLV**	**ROA**	**CGR**
REND	1,000	-0,076	-0,030	0,086	-0,133	0,290	-0,061	0,088	0,036	0,003
BETA	0,027	1,000	0,071	0,036	-0,100	0,041	0,052	-0,062	-0,028	0,107
PER	-0,015	0,071	1,000	0,074	-0,233	-0,078	0,061	-0,143	-0,059	0,136
MTB	0,027	0,036	0,074	1,000	0,025	-0,054	-0,103	0,017	0,414	0,149
DIV	-0,068	-0,100	-0,233	0,025	1,000	-0,108	-0,179	0,096	-0,121	-0,340
MARK	-0,130	0,041	-0,078	-0,054	-0,108	1,000	0,055	-0,024	-0,070	-0,065
CURRAT	-0,020	0,052	0,061	-0,103	-0,179	0,055	1,000	-0,276	0,157	0,089
SOLV	0,076	-0,062	-0,143	0,017	0,096	-0,024	-0,276	1,000	**-0,409**	-0,374
ROA	-0,003	-0,028	-0,059	0,414	-0,121	-0,070	0,157	**-0,409**	1,000	**0,422**
CGR	-0,071	0,107	0,136	0,149	-0,340	-0,065	0,089	-0,374	**0,422**	1,000

The System of Preference

The database consists of 194 securities listed on the U.S market for which information on all the criteria is available[2].

[1] All correlation coefficients are between -0409 and 0422 and so the criteria are not correlated.
[2] Without real investor, we simulated the role of decision maker in MINORA.

Initially, a reference set consisting of 10 shares must be selected and ranked following the preference of the decision maker. The shares of the reference set must be well known by the investor. Furthermore, to perform this ranking, the investor has in Minora system a graphical representation of the criteria sticks which is derived from a pairwise comparison of the reference set shares. From the ranking of the reference set, the UTA algorithm is used and provides functions of piecewise linear marginal utility as compatible as possible with the preorder given by the decision maker.

Table 4: Reference set

Shares	AAPL	NKE	G	WMB	XRX	BC	CL	TUP	OTTR	ESIO
Ranking	1	2	3	4	5	6	7	8	9	10

Analysis of Results

The application of MINORA leads to results shown in Figures 1 to 13. Figure 1 show, in the left panel, the reference set, its ranking by the investor, the global utility for each "reference alternative" and the corresponding ranking. The abscissa in the right figure represents global utility of each "reference alternative" and in ordinate the ranking by the investor of such alternatives. Each point represents an alternative of the reference set. The values of Kendall's τ and F show that the estimated utility function respects almost perfectly the order established by the investor.

Figure 2 shows the global utility decomposition of each alternative of the reference set according to different criteria. These results show that all criteria, at least in the chosen configuration (weight "means"), do have a weight. However, the criterion discriminatory power depends on the shape of the marginal utility function. The higher the slope of the marginal utility function, the higher the importance of the criterion.
In order to assess this discriminatory power, we must carefully observe the marginal utility curves, as well as changes in marginal utility values of a single criterion in Figure 2.

Figures 3 to 12 show the decomposition of the global utility function according to the different marginal utility functions for each criterion. In Figure 3, the table on the left shows for each criterion the range of variation of its weight. The average value (mid) is the one chosen. Furthermore, in Figure 2, we see that the values of marginal utility for return and dividend paid criteria vary greatly between alternatives in the reference set. This suggests that these criteria are highly discriminating between alternatives. This result is confirmed by the shape of the curve àof marginal utility associated with these criteria which have the highest slopes.

Figure 1: The Ordinal regression curve

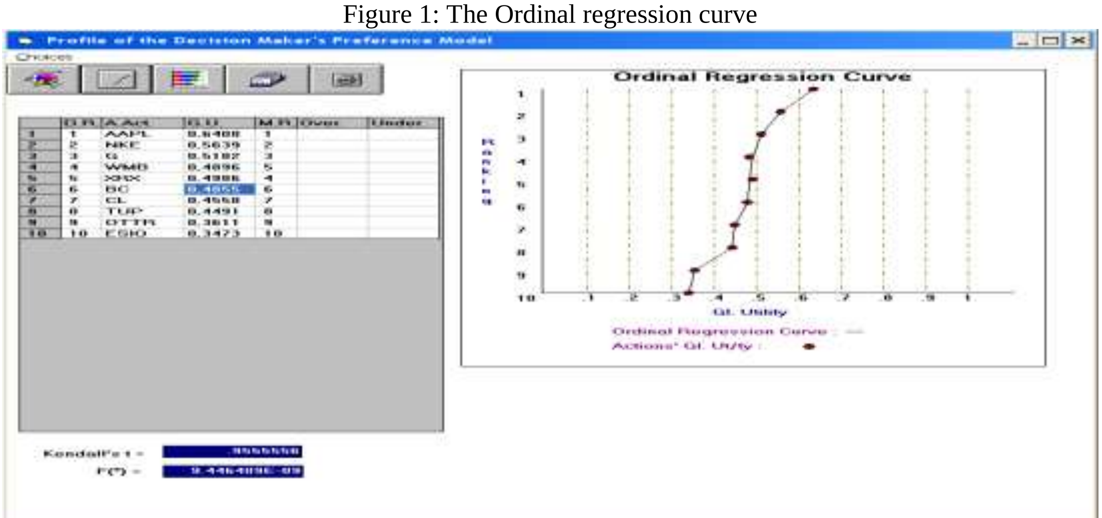

Figure 2: Marginal utilities of the reference set

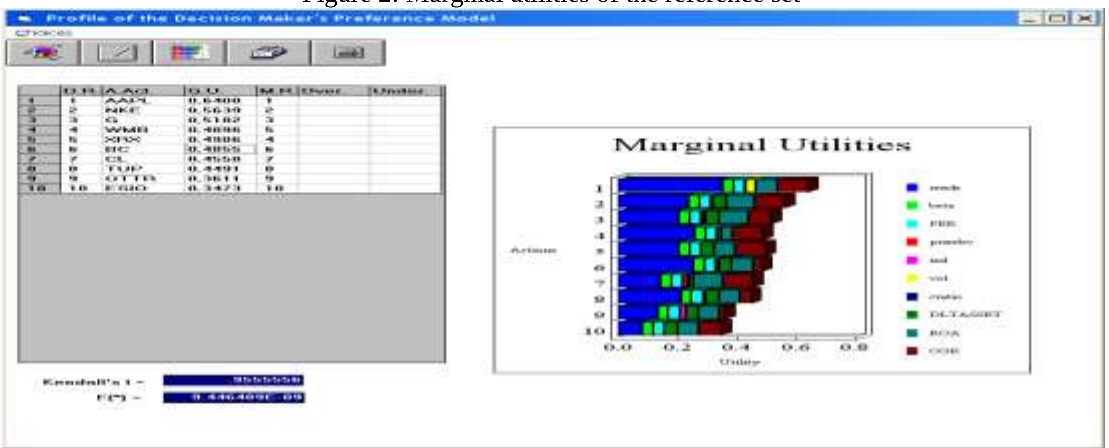

Figure 3: The Expected Return criterion

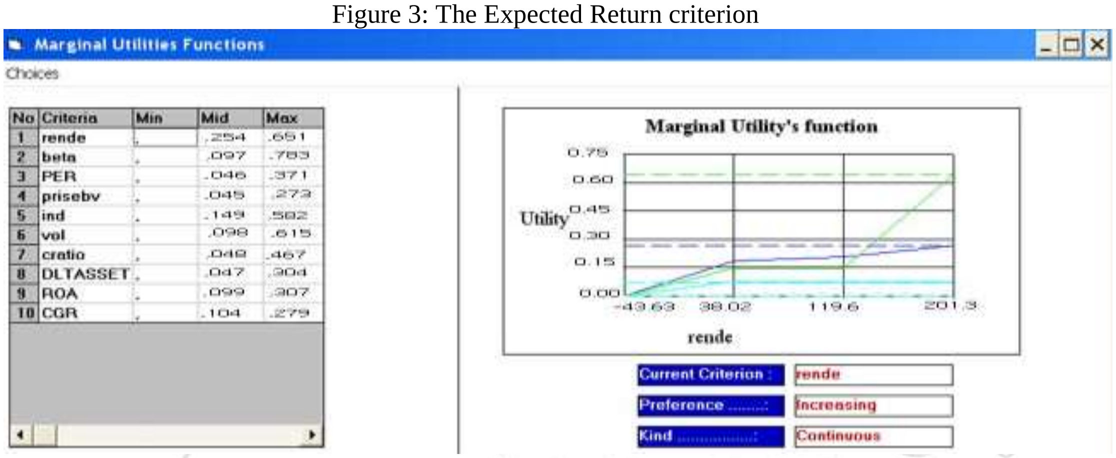

Figure 4: The Beta criterion

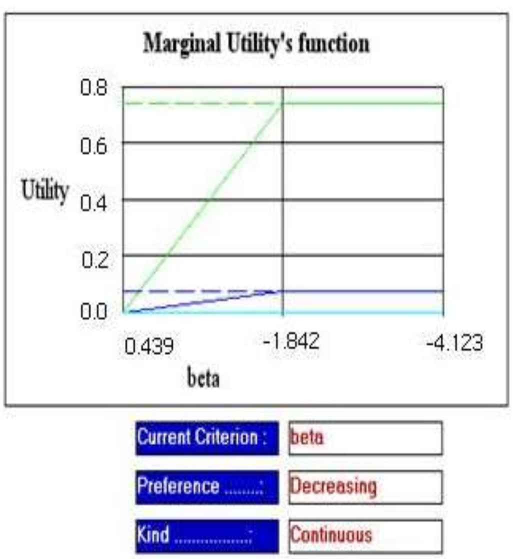

Figure 5: The PER criterion

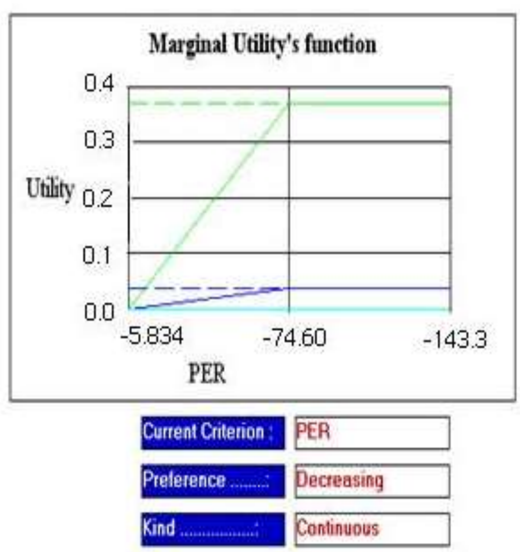

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Figure 6: The Market to Book criterion

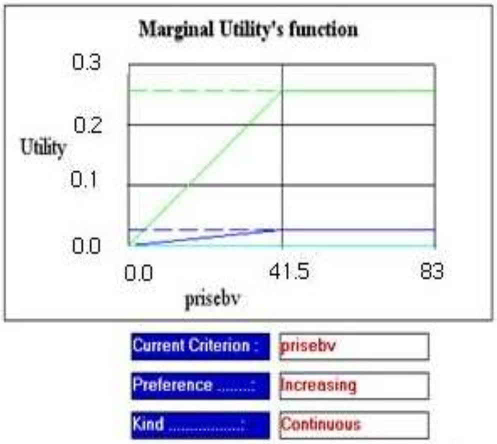


Figure 7: The Dividend paid criterion

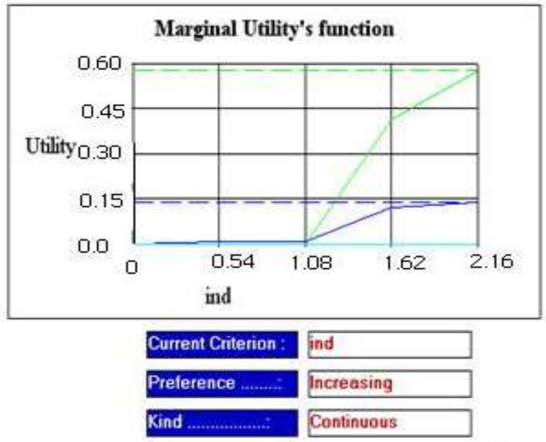


Figure 8: The Marketability criterion

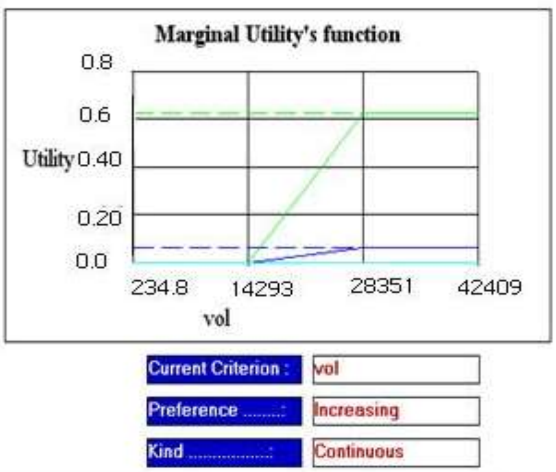


Figure 9: The Current Ratio criterion

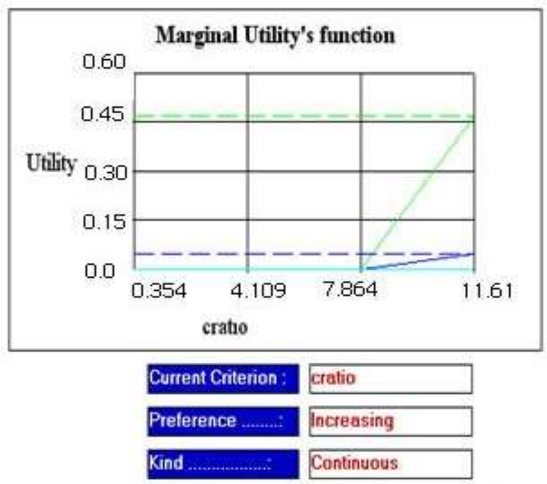


Figure 10: The LT Solvency criterion

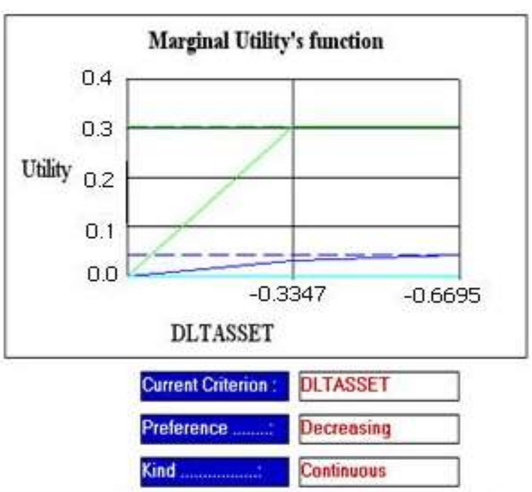


Figure 11: The ROA criterion

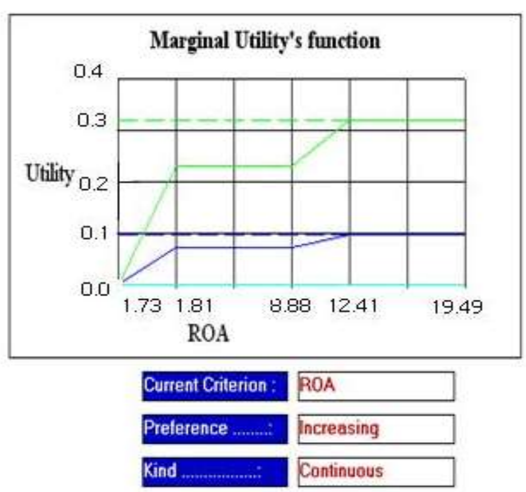
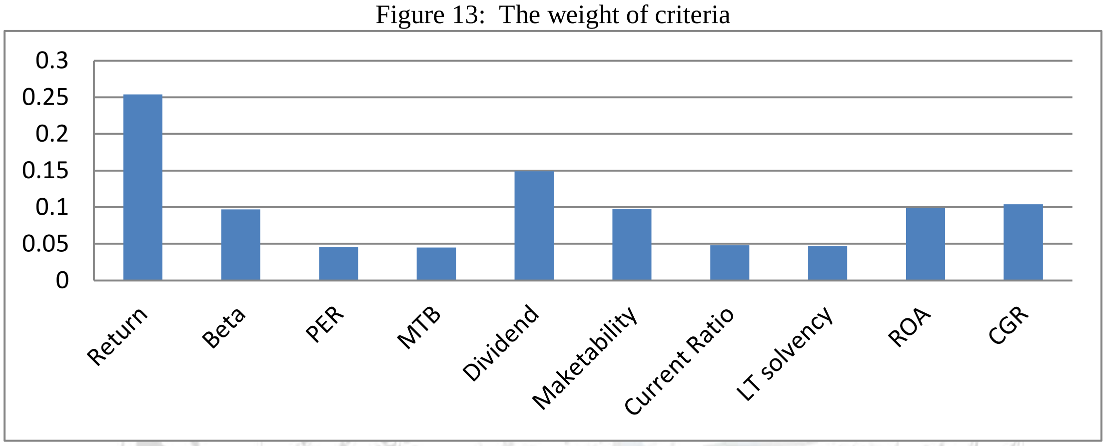


Figure 12: The Corporate Governance criterion (CGR)

Figure 13: The weight of criteria



U(g) = 0,254U_1 (*Return*) + 0,097U_2 (*Beta*) + 0,046U_3 (*PER*) + 0,045U_4 (*MTB*) + 0,149U_5(*Dividend*) + 0,098U_6 (Marketability) + 0,048U_7 (*Current ratio*) + 0,047U_8 (LT *Solvency*) + 0,099U_9 (*ROA*) + 0,104 U_{10} (*CGR*)

The same observation can be made relatively for the criteria Beta, ROA, Corporate Governance and Marketability. In contrast, the results show that the criteria of PER, MTB, Current Ratio and Long Term Solvency do not do a good job of discriminating betwixt alternatives.

Extrapolation of the Results

Interactivity in MINORA is essentially organized around the analysis of inconsistencies between the predetermined order by the investor and the one provided by the model. The method stops when a compromise is determined. The resulting global utility function is then extrapolated to all shares leading to a full ranking.

Table 5 shows the global utility of each alternative (GU), the ranking established by the investor on the reference set (DR) and ranking after final extrapolation of all the studied shares (MR). The interactive search for a weight system is a step that should not be neglected in MINORA. This step becomes more important when there are no inconsistencies between the established order by the investor and the one provided by the model, which is almost the case in this application[3].

[3] Recall that the maximum values of the marginal utility functions (mid) are the relative weights of criteria.

Table 5: Results extrapolation

No	Alternative s	G.U.	DR.	MR.	No	Alternative s	G.U.	DR.	MR.	No	Alternative s	G.U.	DR.	MR.
1	AAPL	0,6408	1	1	66	PEP	0,50682	*	66	131	LEA	0,43744	*	131
2	PGL	0,64	*	2	67	MRK	740,50649	*	67	132	SDS	0,43721	*	132
3	PNW	0,6365	*	3	68	LIZ	0,50545	*	68	133	ACO	0,43586	*	133
4	NPK	0,6363	*	4	69	TJX	0,50393	*	69	134	EASI	0,43508	*	134
5	UTX	0,6315	*	5	70	KEX	0,50327	*	70	135	STRA	0,43337	*	135
6	FE	0,6307	*	6	71	MOT	0,50314	*	71	136	AWR	0,43193	*	136
7	CB	0,6218	*	7	72	PH	0,50305	*	72	137	LUV	0,43042	*	137
8	LAWS	0,62	*	8	73	LFB	0,5024	*	73	138	OMC	0,42969	*	138
9	GAS	0,619	*	9	74	MAS	0,50197	*	74	139	Swx	0,42932	*	139
10	PPG	0,6004	*	10	75	M CD	0,50194	*	75	140	SRCL	0,42626	*	140
11	SJI	0,5966	*	11	76	PD	0,50079	*	76	141	MDT	0,42567	*	141
12	SO	0,5866	*	12	77	HLT	0,50016	*	77	142	WAG	0,42013	*	142
13	MHP	0,5847	*	13	78	GE	0,49979	*	78	143	TEK	0,41952	*	143
14	STTX	0,5839	*	14	79	XRX	0,49863	5	79	144	EC	0,4189	*	144
15	FWRD	0,5793	*	15	80	SFA	0,49779	*	80	145	GNTX	0,41868	*	145
16	CAT	0,578	*	16	81	SGP	0,49731	*	81	146	VMC	0,41395	*	146
17	FELE	0,5756	*	17	82	ESL	0,49545	*	82	147	MSFT	0,40941	*	147
18	URBN	0,5748	*	18	83	PG	0,49468	*	83	148	PNY	0,40917	*	148
19	SONC	0,573	*	19	84	UCL	0,4928	*	84	149	HAS	0,40721	*	149
20	STJ	0,5682	*	20	85	CUNO	0,49095	*	85	150	HDL	0,40671	*	150
21	NKE	0,5639	2	21	86	WMB	0,48958	4	86	151	ARW	0,40352	*	151
22	TXT	0,5635	*	22	87	ROST	0,48875	*	87	152	ANSI	0,40342	*	152
23	WHR	0,5628	*	23	88	TMO	0,48746	*	88	153	MU	0,40174	*	153
24	UNH	0,5616	*	24	89	JLG	0,4866	*	89	154	CBM	0,40123	*	154
25	NUE	0,5599	*	25	90	BC	0,48552	6	90	155	RDC	0,40006	*	155
26	JNJ	0,5587	*	26	91	SIAL	0,48508	*	91	156	RDA	0,39809	*	156
27	TEN	0,5578	*	27	92	RSH	0,48401	*	92	157	NYT	0,39555	*	157
28	NSC	0,5558	*	28	93	MCS	0,48317	*	93	158	SNA	0,39463	*	158
29	TWP	0,5526	*	29	94	DNEX	0,48241	*	94	159	NEM	0,39452	*	159
30	MIKE	0,5525	*	30	95	S	0,48017	*	95	160	FSS	0,39174	*	160
31	HDI	0,5513	*	31	96	TTI	0,47877	*	96	161	MOLX	0,38859	*	161
32	STN	0,5501	*	32	97	KDN	0,47648	*	97	162	CCE	0,38739	*	162
33	TIN	0,5473	*	33	98	KRON	0,47547	*	98	163	FORR	0,38654	*	163
34	CYTC	0,5469	*	34	99	TBL	0,47361	*	99	164	PFE	0,38394	*	164
35	UIC	0,5423	*	35	100	ABT	0,47207	*	100	165	WEN	0,38089	*	165
36	TYC	0,5417	*	36	101	MAT	0,47183	*	101	166	TXN	0,38055	*	166
37	SRT	0,5399	*	37	102	RBK	0,47128	*	102	167	LC	0,37722	*	167
38	WY	0,5393	*	38	103	PBI	0,47051	*	103	168	DCN	0,37609	*	168
39	LMS	0,5392	*	39	104	LNY	0,46995	*	104	169	CV	0,37535	*	169
40	OXY	0,5375	*	40	105	SYY	0,46969	*	105	170	PAYX	0,37292	*	170
41	PKI	0,535	*	41	106	MIL	0,46822	*	106	171	SWY	0,36673	*	171
42	CREE	0,5343	*	42	107	PLL	0,46431	*	107	172	TRB	0,36656	*	172
43	OMM	0,5339	*	43	108	BOL	0,46182	*	108	173	MMS	0,3663	*	173
44	UFP!	0,5337	*	44	109	SRE	0,46071	*	109	174	OTTR	0,3611	9	174
45	TOY	0,5323	*	45	110	CUB	0,45965	*	110	175	AMRI	0,35879	*	175
46	DELL	0,532	*	46	111	NOC	0,45875	*	111	176	FLWS	0,35408	*	176
47	GWW	0,5295	*	47	112	K	0,45721	*	112	177	ALO	0,35352	*	177
48	CPRT	0,5283	*	48	113	WST	0,45714	*	113	178	CTB	0,35339	*	178
49	PCAR	0,5252	*	49	114	ROP	0,45669	*	114	179	MANH	0,35251	*	179
50	BLL	0,5231	*	50	115	UNP	0,45667	*	115	180	LRCX	0,35221	*	180
51	SWK	0,5218	*	51	116	CL	0,4558	7	116	181	ESIO	0,34731	10	181
52	TNB	0,5218	*	52	117	MRCY	0,45576	*	117	182	UVN	0,34705	*	182
53	GM	0,5183	*	53	118	GLT	0,4549	*	118	183	DJ	0,33128	*	183
54	CWT	0,5183	*	54	119	SVU	0,4513	*	119	184	LBY	0,32726	*	184
55	G	0,5182	3	55	120	MAY	0,45001	*	120	185	ADTN	0,32252	*	185
56	JBHT	0,517	*	56	121	TUP	0,44909	8	121	186	TIF	0,31311	*	186
57	CHTT	0,5137	*	57	122	HCR	0,44901	*	122	187	NAV	0,31205	*	187
58	IFF	0,5128	*	58	123	TSG	0,44483	*	123	188	KWR	0,28406	*	188
59	MACR	0,5118	*	59	124	SLGN	0,44288	*	124	189	FRED	0,28109	*	189
60	RMD	0,511	*	60	125	ROH	0,44285	*	125	190	HELX	0,26897	*	190
61	TKR	0,5095	*	61	126	CTXS	0,44039	*	126	191	SBGI	0,2643	*	191
62	TG	0,5087	*	62	127	ROP	0,43926	*	127	192	LTRE	0,24886	*	192
63	SBC	0,5082	*	63	128	WMT	0,43828	*	128	193	LSI	0,2443	*	193
64	BA	0,5079	*	64	129	ABM	0,43819	*	129	194	PLB	0,24313	*	194
65	R	0,5069	*	65	130	KCP	0,43767	*	130					

MINORA system leads to the following additive utility function:
U(g) = 0,254U_1 (*Return*) + 0,097U_2 (*Beta*) + 0,046U_3 (*PER*) + 0,045U_4 (*MTB*) + 0,149U_5(*Dividend*) + 0,098U_6 (Marketability) + 0,048U_7 (*Current ratio*) + 0,047U_8 (LT *Solvency*) + 0,099U_9 (*ROA*) + 0,104 U_{10} (*CGR*)

Assignment of shares by ELECTRE TRI method

In what follows, we propose to assign these same shares to three predefined categories:

- Category 1: "not attractive" shares or shares for sale,
- Category 2: "uncertain" shares or shares to conserve,
- Category 3: "attractive" shares or shares to buy.

Preference System

The application of ELECTRE TRI allows dividing the shares into three categories based on the reference profiles in Table 6.

Table 6: Reference Profiles

	Return	Béta-1	PER	MTB	Dividend	Marketability	Current Ratio	Solvency	ROA	CGR
High Profile	24	0.3	15	4	0.75	1700	2.3	15	8	88
Low Profile	6	0.6	22	2	0.20	800	1.3	30	4	75

ELECTRE TRI is used in this case so that share evaluation can allow for the selection of a number of shares for portfolio constitution. Profiles are specified so that for each criterion, the number of shares is roughly the same in each category. The high profile of a category corresponds to the low profile of the next category, the low profile of the lowest category is the vector of minimum values of the criteria and the high profile of the highest category is the vector of maximum values of criteria (the criteria have been normalized). The assignment of shares in the various categories is then made based on the comparison of these shares with reference profiles. Given that it behooves the investor to weigh the criteria and in order to homogenize the results from both methods, we keep the same criteria and the same weighting system used in MINORA. As for the cutting level λ, the default value is 0.67 (default value chosen by the software). Other values of λ will be used in the sensitivity analysis. λ can be interpreted as the investor's attitude towards the risk. The investor is all the more risk averse when the cutting level λ is high. Indeed, if λ is equal to 1 the outranking relation requires unanimous criteria and we recover the classical concept of dominance. The threshold indifference gives the limit below which the difference between two shares is considered insignificant (for example, a difference less than 1% on the return criterion). The preference threshold gives the smallest difference that must be between two shares so that one is strictly preferred to another on the criterion of interest (for example, the difference of 2 % on the return criterion). As for the veto threshold, they are set for a value equal to the maximum of the threshold[4] so that no criterion can preclude in a unilateral fashion the share assignment in a category.

Table 7: Profile parameters

	Return	Béta-1	PER	MTB	Dividend	Marketability	Current Ratio	Solvency	ROA	CGR
Weight	25	10	5	5	15	10	5	5	10	10
Indifference Threshold	1	0.05	1	0.5	0.05	10	0.1	5	0.05	5
Preference Threshold	2	0.1	2	1	0.1	20	0.2	10	0.1	10
Veto Threshold	201.35	3.12	143.38	83	2.16	42409	11.61	66.95	19.49	100

[4] This is elsewhere the default value of the veto threshold.

Assignment Results

The results of the pessimistic and optimistic assignments are presented in Table 8. When the evaluations of an alternative (a share) are between the two profiles of a category on each criterion, then both procedures assign this alternative to this same category. But if an alternative (a share) is incomparable to one or several profiles, then there is a divergence amongst the results of the two assignment procedures and the pessimistic assignment rule assigns the alternative to a lower category than the optimistic one.

ELECTRE TRI optimistic will therefore be better suited to an optimistic investor who thinks that the market will have an increasing trend or whoever is adept in speculative management. However, ELECTRE TRI pessimistic, more cautious, will be better adapted to a pessimistic investor who believes the market will collapse or whoever is keen on passive management, and therefore clings on to wariness.

However, the best use of ELECTRE TRI is to use the two assignment procedures in order to compare their results. Indeed, the examination of table 8 shows that 76 shares (of 194) are assigned to the same category by both pessimistic and optimistic procedures, of which 44 are assigned to Category 2. So there are 118 shares that change their assignment following the chosen procedure (optimistic or pessimistic). 52 shares of these are assigned to category 2 by the pessimistic procedure and to category 3 by the optimistic procedure. So they can be considered relatively attractive.

In addition, 43 shares are assigned to category 1 by the pessimistic procedure and to category 2 by the optimistic procedure they can be considered not very attractive. However, 23 shares are assigned to category 1 by the pessimistic procedure and to category 3 by the optimistic procedure. These shares are incomparable with the two profiles at the same time; they present a contrasting multicriteria evaluation, making, therefore, their assignment difficult. These alternatives need a special attention from the investor. Indeed, for example, the share STRA has mixed performance: a good marketability, a corporate governance score close to 100%, a good solvency as well as an ROA in the order of 18.44%. However, it has a high PER (overvalued share), low average return and a relatively high β.

Comparison of Results

The assignment of 194 shares in the already defined categories by the ELECTRE TRI method is consistent with the arrangement of shares achieved when applying MINORA method. This helps highlight the good consistency of results obtained with both methods and would strengthen the investor confidence about these results and these methods.

Sensitivity Analysis

In ELECTRE TRI, the shares' assignment depends essentially on the value of the cutting level, the system of weights used and the reference profiles. So, it is along these three axes that the sensitivity analysis will be conducted. To assess the significance of changes that may occur from one assignment to another in the sensitivity analysis, we distinguish two types of changes: changes in type 1 and changes in type 2. The first corresponds to the distance of one category (from category 1 to category 2 or vice versa). The latter, however, corresponds to a difference of two categories (from Category 1 to Category 3 or vice versa). To gauge the proximity of the two assignments, namely the basic sorting obtained above and the sorting obtained after variation of certain parameters of ELECTRE TRI, we used an adaptation of Kendall's τ. To calculate the number of errors of type 1 and type 2, we applied the formula of the Kendall correlation coefficient or Kendall's τ noted:

$$\tau_k(A, A') = 1 - 2\,\frac{d_k(A, A')}{d_k^*}$$

Table 8: Results of the shares classification

	Pessimistic assignment	Optimistic assignment	Shares	Pessimistic assignment	Optimistic assignment	Shares	Pessimistic assignment	Optimistic assignment
AAPL	1	3	KRON	2	3	ROH	2	2
ABM	2	2	KWR	1	2	ROP	2	2
ABT	1	3	LAWS	3	3	ROST	2	3
ACO	2	2	LBY	1	2	RSH	2	3
ADTN	2	2	LC	1	2	S	2	3
ALO	1	1	LEA	1	3	SBC	1	3
AMRI	1	2	LFB	2	3	SBGI	1	1
ANSI	1	3	LIZ	2	3	SDS	1	3
ARW	1	1	LMS	1	3	SFA	2	3
AWR	1	2	LNY	2	2	SGP	1	2
BA	2	3	LRCX	1	2	SIAL	2	2
BC	2	3	LSI	1	1	SJI	1	3
BLL	2	2	LTRE	1	1	SLGN	2	2
BOL	2	2	LUV	1	2	SNA	1	2
CAT	2	3	MACR	2	3	SO	2	2
CB	2	2	MANH	1	3	SONC	1	3
CBM	1	2	MAS	2	3	SRCL	1	1
CCE	1	1	MAT	1	2	SRE	1	3
CHTT	1	3	MAY	2	3	SRT	1	3
CL	1	3	MCD	2	3	STJ	2	3
CPRT	3	3	MCS	1	2	STN	2	3
CREE	2	3	MDT	1	3	STRA	1	3
CTB	1	2	MHP	3	3	STTX	2	3
CTXS	2	3	MIKE	2	3	SVU	2	2
CUB	2	2	MIL	2	2	SWK	3	3
CUNO	1	3	MMS	1	2	SWX	1	2
CV	1	1	MOLX	1	2	SWY	1	2
CWT	2	3	MOT	2	2	SYY	1	2
CYTC	3	3	MRCY	2	2	TBL	2	3
DCN	1	2	MRK	2	3	TEK	1	2
DELL	2	2	MSFT	2	2	TEN	1	3
DJ	1	2	MU	1	2	TG	1	2
DNEX	3	3	NAV	1	1	TIF	1	2
EASI	2	3	NEM	1	2	TIN	2	3
EC	1	2	NKE	3	3	TJX	2	3
ESIO	1	1	NOC	1	2	TKR	2	3
ESL	2	2	NPK	2	3	TMO	2	2
FE	2	2	NSC	2	3	TNB	2	3
FELE	2	3	NUE	2	3	TOY	1	3
FLWS	1	2	NYT	2	2	TRB	1	2
FORR	1	1	ODP	1	2	TSG	1	2
FRED	1	2	OMC	2	2	TTI	2	2
FSS	1	1	OMM	2	3	TUP	2	3
FWRD	3	3	OTTR	1	1	TWP	2	3
G	1	2	OXY	3	3	TXN	1	2
GAS	2	2	PAYX	2	2	TXT	2	3
GE	2	3	PBI	2	2	TYC	2	3
GLT	1	2	PCAR	2	3	UCL	2	2
GM	1	3	PD	3	3	UFPI	2	3
GNTX	2	3	PEP	2	3	UIC	2	3
GWW	3	3	PFE	1	2	UNH	2	3
HAS	1	2	PG	2	3	UNP	1	2
HCR	2	2	PGL	2	2	URBN	3	3
HDI	3	3	PH	3	3	UTX	2	3
HDL	2	2	PKI	2	3	UVN	1	1
HELX	1	2	PLB	1	1	VMC	2	2
HLT	1	3	PLL	2	2	WAG	2	2
IFF	2	2	PNW	2	2	WEN	1	2
JBHT	2	3	PNY	2	2	WHR	1	3
JLG	2	3	PPG	2	2	WMB	1	3
JNJ	3	3	R	2	3	WMT	1	2
K	2	2	RBK	2	2	WST	2	2
KCP	2	3	RDA	1	1	WY	2	3
KDN	2	2	RDC	1	2	XRX	1	2
KEX	2	2	RMD	3	3			

Sensitivity to the Value of the Cutting Level

For the reference assignment, the value of the cutting level λ is fixed at 0.67. We repeat the assignment for successively cutting levels λ = 0.60, λ = 0.75 and λ = 1. Note that the result s'stability after these two changes in the value of λ corresponding to λ = 0.60 and λ = 0.75 is satisfactory. However, the result sensitivity for the extreme case of λ = 1 is significant. Indeed, in this case, the outranking relation is similar to the dominance relation, thus requiring the unanimity of the criteria. Hence it should come as no surprise that to the high values of λ correspond a relatively high number of share assignment changes. The value of cutting level ought to be be fixed with caution especially as the assignment sensitivity depends on the initial cutting level.

Table 9: Sensitivity to the value of the cutting level

	λ = 0.60		λ = 0.75		λ = 1	
	Pessimistic assignment	Optimistic assignment	Pessimistic assignment	Optimistic assignment	Pessimistic assignment	Optimistic assignment
Type 1	44	41	27	20	90	86
Type 2	4	2	1	0	13	15
τ de Kendall	0.714	0.719	0.841	0.875	0.363	0.275

Table 10: Changes in relative weights

	Return	Béta-1	PER	M TB	Dividend	Liquidity	Current ratio	Solvency	ROA	CGR
Reference	25	10	5	5	15	10	5	5	10	10
System 1	30	10	3	3	18	10	3	3	10	10
System 2	22.5	12	4	4	13.5	12	4	4	12	12

Sensitivity to Changes in Relative Weights

We examine herein the sensitivity of the shares assignment resulting to changes in relative weights of criteria. To do this, we proceed in two ways:

1. Increasing by 20% the two highest weights and decreasing by 40% the four lowest weights.
2. Increasing by 20% four median weights and decreasing by 10% two highest weights and by 20% the four lowest weights.

Table 11: Sensitivity to changes in relative weights

	System 1		System 2	
	Pessimistic assignment	Optimistic assignment	Pessimistic assignment	Optimistic assignment
Type 1	8	11	4	2
Type 2	0	0	0	0
Kendall' τ	0.956	0.931	0.978	0.988

Table 11is self-explanatory; the results show that the sensitivity of the assignment to a change in relative weights is almost zero.

Sensitivity to Changes in the Reference Profiles

To assess the shares sensitivity assignment to changes in the reference profiles, they were reduced and increased by 10%. The two pairs of profiles corresponding to these changes are presented in Table 12 and the results of sensitivity analysis in Table 13.

The results in Table 13 show that the stability of the assignment following a change of reference profiles is very satisfactory. Indeed, no change of type 2 appears and the value of Kendall's τ is never less than 0.85.

Table 12: Changes in the reference profiles

	Return	Béta-1	P ER	M T B	Dividend	Liquidity	Current ratio	Solvency	R O A	C G R
High profile	24	0.3	15	4	0.75	1700	2.3	15	8	88
Low profile	6	0.6	22	2	0.2	800	1.3	30	4	75
High +10%	26.4	0.33	16.5	4.4	0.825	1870	2.53	16.5	8.8	96.8
Law +10%	6.6	0.66	24.2	2.2	0.22	880	1.43	33	4.4	82.5
High -10%	21.6	0.27	13.5	3.6	0.675	1530	2.07	13.5	7.2	79.2
Law -10%	5.4	0.54	19.8	1.8	0.18	720	1.17	27	3.6	67.5

Table 13: Sensitivity to changes in the reference profiles

	+ 10%		**- 10%**	
	Pessimistic assignment	Optimistic assignment	Pessimistic assignment	Optimistic assignment
Type 1	17	24	20	15
Type 2	0	0	0	0
Kendall' τ	0.907	0.850	0.890	0.906

Conclusion

The aim of this paper is to construct a model using multicriteria decision aid for the assessment of financial securities. It has been contended that the conventional theoretical approach cannot claim to serve as the sole basis for the practical management of stock portfolios. Effective assessment of financial securities, therefore, requires the joint use of all relevant criteria (fundamental analysis, theoretical and conventional criteria of performance and risk, and even qualitative criteria). We selected the problems of ranking and sorting as they appear to be the major concerns for investors in the assessment of financial securities.

This paper proposes a novel approach for the construction of a multicriteria model for the shares assessment based on an exhaustive list of criteria. It can boast merits in applying the constructive approach to the problems of ranking and sorting in the U.S. market (versus descriptive approach). However, to identify the relevant criteria, we explored the literature and then simulated the behavior of the decision maker, though it would be interesting to go directly to portfolio managers and validate these criteria and parameters for real decision makers.

We have also addressed the issue of share assessment and intend to focus in a forthcoming work on the selection and composition of a stock portfolio based on top-ranked shares by MINORA and/or those assigned in category 3 by the two assignment procedures of ELECTRE TRI.

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