Forming a portfolio using multi-criteria method UTADIS

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1. Introduction

Since the time that the selection among alternative investment proposals became a topic of great interest, a number of researchers have presented various alternative methodologies for the creation of an optimum portfolio of investment products, securities etc. The analysts of securities' markets as well as the investors are interested in models and decision support systems, able to identify the securities that should join in a portfolio providing some sufficient return.

The problem of the construction of a securities portfolio has been faced in a variety of studies. These researches have proposed different methodologies. Elton and Gruber (1987) have presented a review of the techniques applied in the past. More recently, other researchers have used techniques like expert systems (e.g. Suret et al., 1991) and multi-criteria methods (e.g. Zopounidis, 1993 and Zopounidis et al., 1998).

The evaluation of any portfolio proposed is based on the comparison of the return of the portfolio with the return of the respective market expressed by the growth of the General Index or any other appropriate market Index. Therefore, the ideal portfolio would be the one comprised of securities that will yield a return higher than the return of the index, so that the whole portfolio will yield a return higher than the return of the index. In this context, it is important to provide an automated system for the analysis and evaluation of the available securities, able to support effectively the investment decision. There is a number of methods proposed in the literature, for the construction of portfolios that will yield a return, higher than the return of some index. Such proposals are those of Gold and Lebowitz (1999) using moving average techniques and of Eakins and Stansell (2003) that used neural network models to create portfolios that yield a return higher than the DJIA and S&P 500 indexes.

The selection of the methodology for the development of a portfolio construction model is a very important issue as the models should provide significant, high quality and justified proposals. In addition, the models have to be easily understandable by the potential users, i.e. investors or analysts. Finally, the ability of these models to be easily revised can be considered as the most important parameter for the methodology selection. The revision is necessary if the market conditions or other important factors of the economic environment change and theses changes reflect to some change in the preferences or estimations of the decision makers.

This paper makes the proposal of the multi-criteria method UTADIS for the formulation of a model able to discriminate the set of the available securities in a market into two classes. The one class includes the securities that are expected to yield a return exceeding the return of the market index and the second class includes those securities that are expected to yield a return below the return of the market index.

The security selection problem can be faced as a multi-criteria problem as its modeling contains the main characteristics of multi-criteria problems. Specifically (cf. Roy, 1988), the problem is characterized by:

(a) multiple criteria,

(b) conflict situation between them,

(c) complex evaluation process that is subjective and ill-structured, and

(d) introduction of decision makers (security analysts or investors) in the evaluation process.

The proposal of a multi-criteria method was made as these methods can be very useful tools in business administration and especially in financial analysis discrimination problems as:

- they are free of statistical hypotheses and restrictions,
- they can handle easily quantitative (e.g. financial and market ratios) or qualitative criteria as well as any combination of them,
- they can incorporate the knowledge and preferences of the decision makers in the decision analysis process and modeling,
- the models can be easily reviewed, taking into account the dynamic nature of the decision process, the changes in the economic environment as well as any changes in the decision maker's preferences and,
- the models are easy for the users to understand and to validate the results and
- the methods can be used as educational tools for the users and the accountants when they prepare the reports and financial statements.

For the evaluation of the securities in this paper, we employed UTADIS method that is a multi-criteria method formulated for the discrimination of objects in predetermined groups. For the illustration of the application of the method, we employed the financial characteristics of the companies, as derived from the publicized financial statements (Balance Sheet and Income Statement) in combination with indicators of the market behavior of the securities. For this application, we utilized the knowledge and the experience of an expert market analyst (Greek stock market) for the selection of the evaluation criteria. This provided the ability to analyze the investment decision and to evaluate the importance of the criteria in the securities selection. The paper is organized as follows: Section 2 introduces the methodology applied and the UTADIS method, Section 3 presents the model development procedure making use of Athens Stock Exchange (ASE) data, as well as the models developed, section 4 presents the results from the application of the models and section 5 provides some conclusions and future directions for research in the area.

2. Methodology

For the creation of a portfolio able to provide a return superior than the return of a market index, the main step is the formulation of a model able to select among the available securities and to propose the securities that should be included in the portfolio. In this framework, the set of the available securities in the market should be divided into two subsets: the set that is comprised by securities that are accepted to enter the portfolio and the set of the non accepted securities. After the definition of the two subsets, the next step is to define the set of the appropriate criteria to be employed by the classification model and then the estimation and the validation of the model. Then the model is available to be applied and provide suggestions to the users. This procedure is presented in Figure 1. At any step, after the group definition, in practice, the analyst can return to a previous step in order to make any modifications needed. These modifications can be the result of the weakness of the model to provide satisfactory results, the changes in data availability, the experience of the analyst, etc. or any combination of them. This procedure is presented in Figure 1.

For the formulation of a securities selection model, we propose UTADIS (UTilités Additives DIScriminantes) method. UTADIS is a member of the wider family of the multi-criteria methods. These methods have already been used in financial management problems that can be faced as grouping or discrimination problems, like business failure, credit granting, venture capital, securities selection (c.f. Dimitras, 1995; Zopounidis and Dimitras, 1998; Doumpos and Zopounidis, 1998; Dimitras A., 2002; and Dimitras A., Petropoulos T., Constantinidou I., 2002).

UTADIS method, presented by Doumpos and Zopounidis (1998) is a variant of monotone regression method UTA (Jacquet-Lagreze and Siskos, 1982). Given a grouping of the objects (or alternatives) under examination and a consistent family of criteria (c.f. Roy and Bouyssou, 1987), the target of the method is to provide an additive utility function and the utility thresholds that provide a classification of the objects in the predetermined groups with the minimum error. The calculation of the additive utility function and the thresholds is based on linear programming methods (c.f. Doumpos and Zopounidis, 1998).

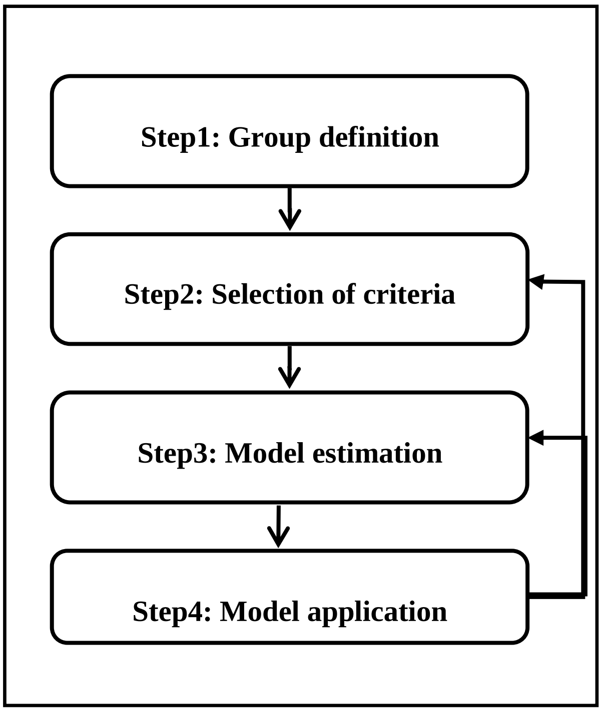

Figure 1: The Model building procedure.

Analytically, given that g1, g2, ..., gm is a set of m evaluation criteria, and A= {α1, α2, ..., αn} a set of n objects to be grouped in Q groups named C1, C2, ..., CQ, a priori defined as:

C1 P C2 ... CQ-1 P CQ,

where P stands for strict preference of a group over another.

The global utility U(α) of an object α∈A is of the form:

$$U(\alpha) = \sum_{i=1}^{m} u_i[g_i(\alpha)],$$

where $u_i[g_i(\alpha)]$ is the marginal utility of object α for criterion gi. Marginal utilities represent the relative importance of the criteria in the model.

The calculation of the marginal utilities $u_i[g_i(\alpha)]$ and the utility thresholds uk is made through the solution of the following linear program (c.f. Zopounidis Doumpos, 1999):

$$[\text{minimize}]\ F = \sum_{\alpha\in C_1} \sigma^{+}(\alpha) + \ldots + \sum_{\alpha\in C_k} [\sigma^{+}(\alpha) + \sigma^{-}(\alpha)] + \ldots + \sum_{\alpha\in C_Q} \sigma^{-}(\alpha),$$

under the constraints:

$$\sum_{i=1}^{m} u_i\left[g_i(\alpha)\right] - u_1 + \sigma^{+}(\alpha) \geq 0 \qquad \forall \alpha \in C_1$$

$$\sum_{i=1}^{m} u_i\left[g_i(\alpha)\right] - u_{k-1} - \sigma^{-}(\alpha) \leq -\delta \qquad \forall \alpha \in C_k$$

$$\sum_{i=1}^{m} u_i\left[g_i(\alpha)\right] - u_k + \sigma^{+}(\alpha) \geq 0 \qquad \forall \alpha \in C_k$$

$$\sum_{i=1}^{m} u_i\left[g_i(\alpha)\right] - u_{Q-1} - \sigma^{-}(\alpha) \leq -\delta \qquad \forall \alpha \in C_Q$$

$$\sum_{i=1}^{m} \sum_{j=1}^{a_i - 1} w_{ij} = 1$$

$$u_{k-1} - u_k \geq s \qquad k = 2,3,\ldots,Q-1$$

$$w_{ij} \geq 0, \sigma^{+}(\alpha) \geq 0, \sigma^{-}(\alpha) \geq 0,$$

where δ is a small positive real number that is used in order to define the strict inequality of U(α), of uk-1 (∀α∈Ck, k>1) and of uQ-1 (∀α∈CQ). Threshold s is used to express the strict preference between the utility thresholds (s > δ > 0).

For the classification of any new object β, the global utility of the object U(β) is compared to the utility thresholds ui (where u1 > u2 > ... > uQ-1) that the method calculates. The classification is made according to the scheme:

$$U(\beta) \geq u_1 \qquad \Rightarrow \beta \in C_1$$

. . . .

$$u_k \leq U(\beta) < u_{k-1} \qquad \Rightarrow \beta \in C_k$$

. . . .

$$U(\beta) < u_{Q-1} \qquad \Rightarrow \beta \in C_Q$$

Except from the classification of the objects, it is important that the method provides a ranking of the objects, already classified into any group, according to their global utilities.

The method provides not only a grouping of the objects but can also provide some sorting of the objects into a group accordingly to the global utility of the objects. This ranking can be very useful, if one requires to select some of the objects classified in any class (for example the ten first) according to their global utility.

UTADIS models can be used for the construction of a securities' portfolio, by dividing the available securities into two groups C1 and C2, defined as follows:

(a) the C1 Group, that consists of "high return" securities that is the securities that are expected to yield a return higher than the return of the market index and

(b) the C2 Group, that consists of the “low return” securities that is the securities that are expected to yield a return lower than the return of the market index.

The return $R_t(\alpha)$ of the stock α for year t is defined as:

$$R_t(\alpha)=\frac{P_t(\alpha)-P_{t-1}(\alpha)}{P_{t-1}(\alpha)},$$

where $P_t(\alpha)$ is the price of the stock α at the end of year t.

Similarly, the return $R_t(I)$ of an index I for year t is defined as:

$$R_t(I)=\frac{P_t(I)-P_{t-1}(I)}{P_{t-1}(I)},$$

where $P_t(I)$ is the price of the stock α at the end of year t.

For the application of the above stock return definition, we have to transform the prices of the securities in the cases of changes such as splits, reverse splits etc. It has to be mentioned that this definition ignores the dividend return of the securities.

It is obvious that the securities classified in the C1 Group compose a portfolio that is expected to provide a return higher than the return of the market index. This holds for any composition of the portfolio. The exact return of the portfolio depends on the return of the specific securities selected and the contribution of each stock in the portfolio.

As for the analysis of the classification success of such a method, it has to be mentioned that the classical classification accuracy analysis using Type I and II errors might be of no sense in this case. It is more important to perceive the expected return of the proposed portfolio in order to evaluate the model and the portfolio in relation to the scope of the model that is the construction of a securities portfolio providing a return higher than the market index return. A high classification accuracy does not ensure a portfolio return higher than the market index return although the more the “high return” securities in the portfolio the higher possibility for the portfolio to obtain a return of the desired level. However, it is possible to obtain a high return even if some of the securities in portfolio are of low return if the contribution of them is not important.

As for the contribution of the selected securities in the portfolio there are various techniques proposed in the literature in order to construct an optimum portfolio. Such techniques are often ignored in practice. The difficulties in the application of these methods and the inability to validate the results of them make financial analysts and investors not to trust always their propositions. However, this issue is beyond the scope of this paper. This research focuses on the selection of the securities and we presume that, in any case the analyst or the investor, taking into account additional criteria, will make the final decision.

3. Model development

For the illustration of the application of the method in this paper, data collected are those of the common stocks in the Main Market of The Athens Stock Exchange for the period 1995-2002. During this period, the number if the listed companies in ASE and the General Index of the market increased in large. Changes in the government policy and legislation, the privatization of large state-owned companies as well as the mass entering in the stock market of large amounts of capital from medium and small income investors were some of the important phenomena of this period 1995 -1999. The next three years 2000-2002 the prices of securities declined dramatically. Although this decline was not supported by the publicized financial data of the firms, the drop in the prices was the result of the negative climate in the financial markets worldwide and the disappointment of the investors that started selling their portfolios in very low prices.

For the needs of this study, in order to form a homogenous set of securities and evaluation criteria for them as well as to ensure the maximum continuity of data we omitted some securities from the total of the securities listed in ASE, during the period 1995-2002. First, we left out the securities of the banking and financial sector. This exclusion was due to the important differences in the financial reports and characteristics between the financial firms and the rest of the firms. Second, we excluded the securities that were listed out during the above period. These exclusions are related to firms that terminated their operations as well as firms that were merged or acquired. After these modifications, the final set of securities presents a satisfactory homogeneity and continuity of data for the above period.

The number of the available securities for each year increases from 103 in the first year (1995) to 268 in the last year (2002). This change is following the dramatic increase to the total number of firms listed in ASE during the same period. In addition, we can observe changes in the industry that these firms come from. For 1995, the 17% of the firms belong to the wholesaler industry that holds the larger percentage among the industries. For 2002, the wholesaler firms are still one of the larger parts (3%) but construction and textile industry firms are obtaining the same proportion.

For the development of the models we used the financial and market stock data available for year N and the securities returns for year N+1 in order to provide a model able to discriminate between the “high return” and “low return” securities for year N+1, based on the data of year N. The model developed is called the “Year N” model and can be used to classify securities and consequently propose portfolios for the years N+1, N+2, etc. The evaluation of the models can be made using two different strategies. The first strategy consists in using Year N model for the construction of portfolios for all the next years N+1, N+2, etc. This means that the 1995 model is employed to construct portfolios for the years 1996, 1997, …, 2002. This strategy ensures stability in the securities selection procedure and in the portfolio propositions. Of course, the portfolio proposed for year 1996 has only theoretical importance. In practice, the Year N model cannot be employed for portfolio construction for the year N+1, in the same way it can be used for the rest of the years. Actually, the portfolio proposed by the Year N model for year N+1, is employed only for the evaluation of the Year N model, and is called "evaluation" portfolio.

Obviously, this strategy does not make use of the ability of multi-criteria method UTADIS to re-new, with a relatively low cost, the models when the economic conditions or the preferences and judgments of the decision makers change. In order to benefit from this ability, we employed a second strategy, according to which the models are re-evaluated each year according to the latest data. This way, each model is used in practice for one time and then a new model is created and applied. Therefore, the 1995 model is used to propose a portfolio for 1997, the 1996 model is used to propose a portfolio for 1998 etc.

For the development of the models, at first a large set of criteria was derived for the securities involved in this analysis. These criteria were the accounting ratios available, in order to obtain information on the financial condition of the firms as presented in various studies (e.g. Courtis; 1978), as well as investor indexes providing market information on the securities. More information on the on investor indexes provide Alexander and Sharpe (1989) and Copeland and Weston (1983) among others. From this large set of criteria, a smaller set was selected.

This selection was targeting to provide a set of criteria able to discriminate the securities into the two predetermined groups C1 and C2 using UTADIS method. The criteria selection procedure was based on an initial statistical analysis of the criteria and, mainly, on the experience of analysts on the Greek stock market. This procedure required several trials in order to obtain a consistent family of criteria to be used throughout the whole period under analysis.

The criteria finally selected and employed in the models are 15. From these 15 criteria, the first 5 are investor indicators and the rest of them are accounting ratios. Table 1 presents the set of criteria selected as well as indicates the increasing or decreasing preference for each criterion. The symbol '↑' or '↓' next to each criterion denotes the increasing or decreasing preference for the criterion, respectively. Preference is characterized increasing when the higher the value on the criterion then the higher the preference. In the same way, preference is characterized decreasing when the lower the value on the criterion then the higher the preference.

Table 1: Criteria and preference

Criteria	Preference
g_1: Stock price Return	↑
g_2: Price to Earnings Ratio (P/E)	↓
g_3: Price to Book Value Ratio (P/BV)	↓
g_4: Capitalization to Sales (P/S)	↓
g_5: Dividend Yield	↑
g_6: Current Ratio	↑
g_7: Quick Ratio	↑
g_8: Debt Ratio	↓
g_9: Inventory Turnover	↑
g_{10}: Total Assets Turnover	↑
g_{11}: Net Profit Margin	↑
g_{12}: Gross Profit Margin	↑
g_{13}: Return on Shareholders' Equity	↑
g_{14}: Return on Assets	↑
g_{15}: Sales to Net Worth Ratio	↑

As mentioned earlier, all the models developed in this study, employed the same 15 criteria. This choice was made to enable comparison of the importance of the criteria across the models. Alternatively, we could use a new set of criteria for each year of the analysis, but, in this case, the results would probably be affected in large by the criteria set and the models would not be easily comparable.

The marginal utilities and consequently the importance of each criterion were proved different in each model. Table 2 summarizes the marginal utilities estimated for the criteria. As we can easily derive from Table 2, the most important criterion is different in each year's model, and no criterion can be considered as the most important. For the most of the models, criteria g1 (Stock price Return) and g5 (Dividend Yield) seem to be of relatively higher importance, and no criterion is of low importance for all the models. Figure 2 presents the marginal utilities diagrams of the criteria for the 1995 model.

Table 2: Marginal utilities of criteria

Criterion	Year						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
g_1	12,00%	18,29%	11,22%	12,51%	11,13%	12,47%	0,01%
g_2	0,09%	0,03%	0,04%	0,01%	1,32%	33,15%	18,18%
g_3	6,00%	6,30%	0,23%	0,06%	0,41%	0,46%	0,03%
g_4	6,33%	6,25%	24,16%	6,26%	6,25%	0,47%	0,11%
g_5	11,95%	12,11%	6,25%	18,58%	6,25%	6,25%	6,55%
g_6	6,00%	6,29%	6,25%	6,25%	6,28%	0,65%	6,23%
g_7	6,00%	6,25%	6,25%	6,25%	6,25%	0,46%	6,23%
g_8	6,01%	6,29%	6,25%	6,25%	6,25%	1,04%	6,36%
g_9	6,00%	0,14%	6,45%	6,25%	6,25%	6,25%	6,23%
g_{10}	6,01%	6,26%	1,46%	6,26%	12,11%	6,37%	6,23%
g_{11}	6,30%	6,25%	6,25%	6,25%	6,25%	6,25%	12,61%
g_{12}	6,09%	6,28%	6,25%	6,27%	8,52%	7,42%	6,32%
g_{13}	6,01%	6,28%	6,25%	6,29%	6,25%	6,25%	12,39%
g_{14}	6,00%	6,25%	6,25%	6,25%	10,23%	6,25%	6,23%
g_{15}	9,20%	6,74%	6,43%	6,25%	6,25%	6,25%	6,29%

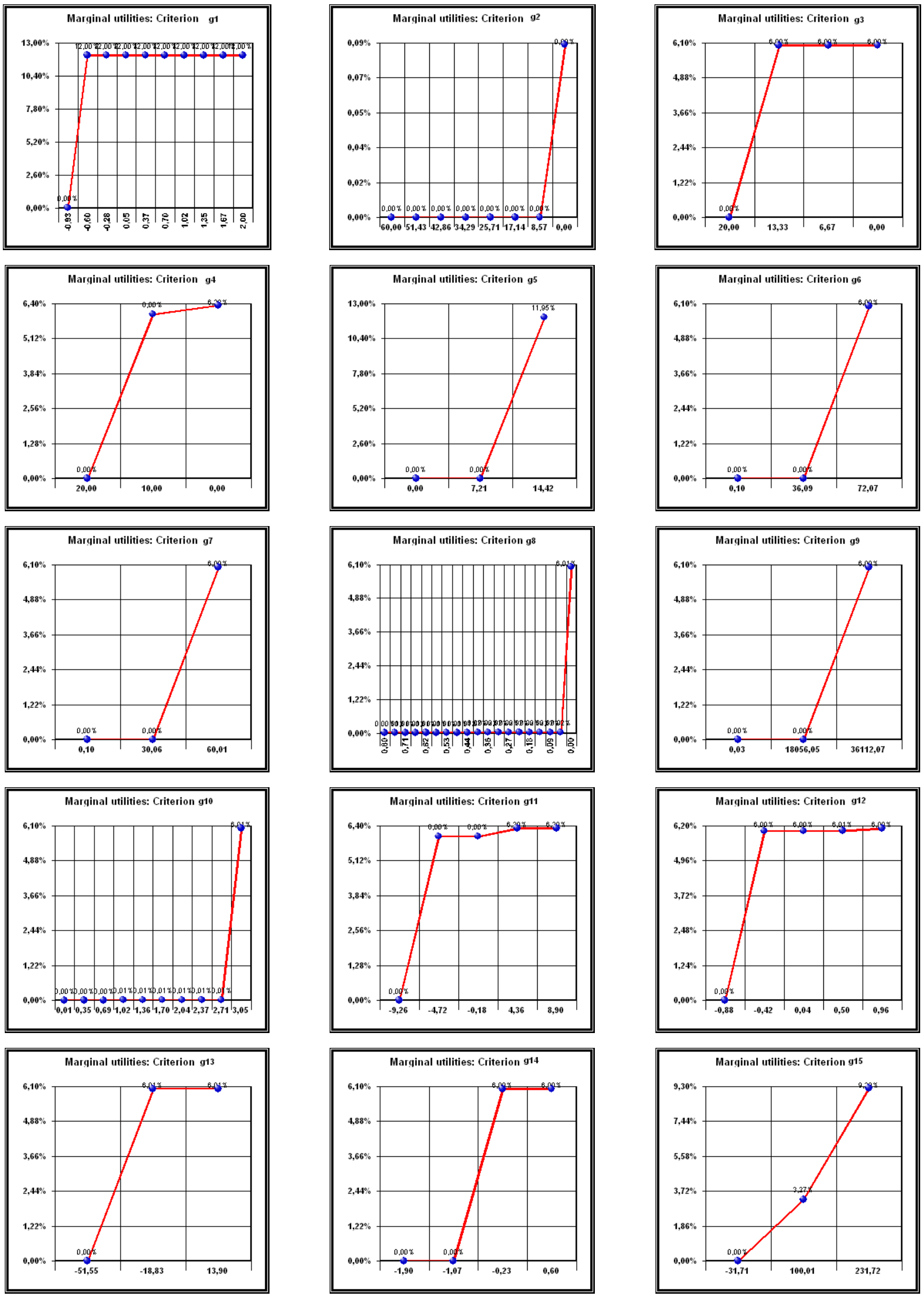

Figure2: Marginal utility diagrams for the 1995 model.

Table 3 presents the global utility thresholds used for the two group discrimination for each model. The application of these thresholds provides the securities to be included in the proposed portfolio for the next years of the analysis.

Table 3: Utility thresholds for the models

Model	Utility thresholds
1995	0,4928
1996	0,4988
1997	0,5101
1998	0,3764
1999	0,3237
2000	0,4080
2001	0,4087

4. Results

Table 4 presents the return of the proposed portfolios for each year, using the proposed models and equal amounts placed to each security. We have to mention that the number of securities in each portfolio varies according to the model and the year of estimation. The return of the "evaluation" portfolios is, in most cases, superior to the ASE GI return for the same year. Only for the years 1997 and 2000, the ASE GI return is superior to the return of the "evaluation" portfolios. This can be explained, at least partially, by the fact that these years are related with the beginning of the strong increase and the strong decrease of the ASE GI respectively. This unusual behavior of the GI during the period under analysis, as well as the fact that ASE GI is affected in large by securities of the financial industry, which are excluded in the present study, are very important factors that have to be taken into account for the evaluation of the results.

Table 4: The return of the proposed portfolios

Model	Year						
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
1995	12,34%	67,50%	180,70%	1.144,54%	-65,75%	-15,43%	-20,82%
1996		31,75%	124,03%	4.362,40%	-74,09%	-15,86%	-43,91%
1997			128,95%	487,71%	-65,04%	-42,99%	-47,47%
1998				8.488,43%	-75,92%	-8,35%	-43,47%
1999					-64,81%	-18,56%	-38,64%
2000						-19,91%	-20,72%
2001							-34,07%
GI return	2,11%	58,54%	85,00%	102,15%	-38,77%	-23,52%	-32,56%

Further, Table 4 can state the successful use of the models developed using UTADIS method. As it can be easily derived, the return of the proposed portfolios is, in the most of the cases, superior to the ASE GI return. Both of the strategies described above provide rather satisfactorily results.

In the case of the first strategy that makes use of one stable model for the proposition of portfolios for all the years following the development of the model, the results are very sound. For example, Figure 3 presents the return of the portfolios provided by the 1995 model for the years 1997-2002 in comparison with the return of the ASE GI. An investor who would have invested in securities listed in ASE using the specific model could achieve for the most of the years and in total a return higher than the ASE GI return. The total return of the ASE GI for the period 1997-2002 is 150.84 % and the return of the proposed portfolios is 1290.74%. It has to be mentioned that especially for year 1999 the return of the proposed portfolio is more than ten times the return of the ASE GI. This extremely high return is followed by an extremely negative return for year 2000 that is the only year that the return of the proposed portfolio does not outperform the return of the ASE GI. If we omit the returns of 1999 then the total return of the ASE GI is 48,69% and the return of the proposed portfolios is 146,20%.

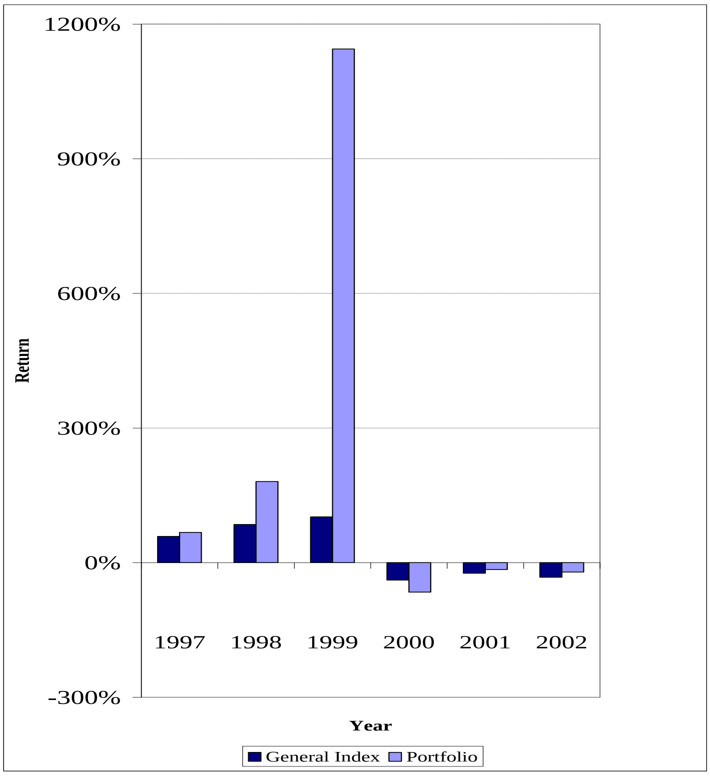

Figure 3: Comparison of the ASE GI return with the portfolios proposed by 1995 model ("stable" model strategy).

Similar results to the above can be derived if we use the rest the rest of the models applying the first strategy. What can be stated is that, when data from the years 1999 and 2000 are involved in the portfolio proposal (data for the model construction or data for the securities under evaluation), then the return of the proposed portfolios is lower than the return of the ASE GI, following the abnormally extreme trend of the whole market.

The results are not much different in the case of the second strategy, which involves re-estimation of the model for each year. Figure 4 presents the price return of the proposed portfolio in comparison with the ASE General Index return, using the second strategy. In this case, the return of the proposed portfolio outperforms the return of the GI for all the years with the exception of the year 2000. This exception follows the abnormal behavior of the ASE GI. The overall return of the proposed portfolios for the period 1997 – 2002 is 564.04% that outperforms the return of the ASE GI (150.84%) for the same period. Again, if we omit the extreme returns of 1999 and the overall return of the proposed portfolios is 76.33% and outperforms the overall return of the ASE GI(48,69%).

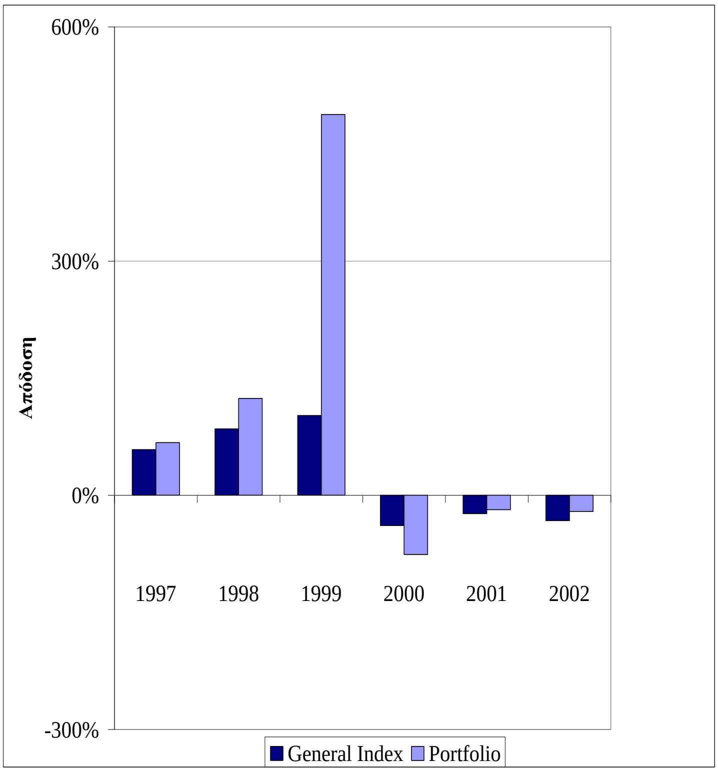

Figure 4: Comparison of the ASE GI return with the portfolios proposed by UTADIS models (re-estimation model strategy).

In, general the results provided from the application of UTADIS method using both strategies have been proved to be satisfactory and the proposed portfolios have provided returns exceeding the return of the ASE GI. Obviously, the application of the method by the financial analysts and investors can drive to some sound propositions for the portfolio construction.

5. Conclusions

In this study we presented a methodology based on multi-criteria method UTADIS to develop models able to classify securities and construct portfolios providing a return exceeding the market index return. The securities are classified into two groups: the group of the securities with an expected return superior to the market index return and a group of securities with an expected return lower than the return of the market index. The securities classified into the first group are those to be included in the portfolio under construction. For the illustration of the methodology, we employed data (accounting and market ratios) of the securities available in Athens Stock exchange during the period 1995-2002 (excluding the securities of the banking/finance sector) and the experience of a market analyst. The application of the method, using two different strategies (stable or re-estimated models) are rather encouraging. The resulting portfolios obtain a return that, in the most of the cases, is superior the return of the General Index of the market. In spite of the abnormal situation and the excessive variation of the ASE GI during the period under analysis, the overall return of the proposed portfolio outperforms the return of the GI.

Investors (companies of individuals) or analysts can easily adopt the methodology presented to support the decision making on the securities selection. Of course, the adoption of the method requires a careful analysis of the market and the securities in order to construct models that will reflect the preferences and the experience of the decision makers, and, at the same time, take into account the current economic conditions and trends.

The limitations of this work can guide the future research. First, there is a need to evaluate securities from the banking and financial sector among others. Therefore, some modification has to be employed in order to widen the evaluation procedure and include banking and financial sector securities in the decision model. This is very important in the case of the Greek Securities Market where the GI is affected in large by securities of the banking sector. The addition of these securities can help in developing of more robust models and superior returns.

Next, some non-quantitive criteria could be used in the decision process, as the proposed methodology can support the use of qualitative / strategic criteria in the evaluation procedure. Resent studies, as well as the analysts practice propose the use of such criteria for security selection. On the other hand, current databases provide little and not systematic information on the qualitative characteristics of the securities. For the adoption of qualitative criteria, the decision makers have to elaborate information from various sources and to form criteria incorporating the qualitative information.

Furthermore, the wide adoption of IRFS will force the market analysts to re- assess the usefulness of specific accounting ratios on the evaluation of the securities in a market. This re-assessment will reflect in changes in the criteria to be employed by evaluation models.

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