A MULTICRITERIA APPROACH FOR THE ANALYSIS AND PREDICTION OF BUSINESS FAILURE IN GREECE

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UNE APPROCHE MULTICRITERE POUR L'ANALYSE ET LA PREVISION DU RISQUE DE DEFAILLANCE EN GRECE

Résumé
Dans cet article la méthode multicritère ELECTRE TRI est utilisée pour faire la discrimination entre entreprises saines et défaillantes en Grèce. Un modèle approprié a été construit selon les connaissances financières déjà existantes et l'expérience passée. Un échantillon de 60 entreprises (30 défaillantes/30 saines) a été utilisé pour évaluer la capacité de la méthode à prévoir la défaillance des entreprises. Les résultats obtenus sont comparés à ceux fournis par l'analyse discriminante. Les résultats de l'étude montrent que la méthode ELECTRE TRI semble avoir un rôle très promoteur dans le domaine de la prévision de défaillance des entreprises.

A MULTICRITERIA APPROACH FOR THE ANALYSIS AND PREDICTION OF BUSINESS FAILURE IN GREECE

Abstract
In this paper the multicriteria method ELECTRE TRI is employed to make the discrimination between failed and healthy firms in Greece. An appropriate model was built according to the financial knowledge and past experience. A sample of 30 bankrupt firms matched to a sample of 30 healthy firms is used to evaluate the capability of the method for the prediction of business failure. The results are compared to those derived by a discriminant analysis model. The results using ELECTRE TRI promise satisfactory applications in the domain of financial distress.
1. INTRODUCTION

The prediction of business failure is a field in which many researchers have been working for the last two decades. As a matter of fact, banks, financial institutions, clients, etc., need such predictions for firms in which they have an interest.

One of the first methods for the prediction of business failure used multivariate discriminant analysis (DA) proposed by Altman in 1968. He proposed a discriminant function with 5 variables for evaluating the risk of business failure. Subsequently, the use of this method has continued to spread to the point where today one speaks of discriminant models of evaluating business failure risk. But, at the same time, the generalization of this method has given rise to numerous studies which criticize it. Eisenbeis (1977) mentioned 7 possible pitfalls in the utilisation of DA: the violation of the distribution assumptions of the variables; inequality in group dispersions; the interpretation of the significance of individual variables; the reduction of dimensionality; the definitions of the groups; the choice of the appropriate a priori probabilities and/or costs of misclassification; the estimation of classification error rates.
set of alternatives evaluated by quantitative and/or qualitative criteria and from a set of
categories corresponding to predefined recommendations or norms, ELECTRE TRI
proposes two different classification procedures that allow the grouping of alternatives in the
prescribed categories. The categories are conceived independently of the set of alternatives
and ELECTRE TRI deals with ordered categories (complete order). These categories are
defined by some reference alternatives or reference profiles which are themselves defined by
their values on the criteria.

Following this, we can define the categories \( C_i \), \( i = 1, \ldots, k \), where \( C^1 \) is the worst
category and \( C^k \) the best one. We can also define the profiles \( r_i \), \( i = 1, \ldots, k-1 \), where \( r^1 \) is
the lower profile and \( r^{k-1} \) the upper. Then the profile \( r^j \) is the theoretical limit between two
categories \( C^i \) and \( C^{i+1} \) and \( r^i \) is strictly better than \( r^{i+1} \) for each criterion.

In ELECTRE TRI, the information asked from the decision maker about his
preferences takes the form, for each criterion and each profile, of a relative weight and
indifference, preference, and veto thresholds. Concerning classification, ELECTRE TRI
compares the alternatives with the profiles using the classical concepts of concordance
index, discordance index and valued outranking relation as ELECTRE III method (cf. Roy
and Bouyssou, 1993). Between an alternative \( a \) and a profile \( r^j \), the concordance index
\( c_j(a, r^j) \) expresses the strength of the affirmation "alternative \( a \) is at least as good as profile
\( r^j \) on criterion \( j \)", and for an increasing criterion \( j \) is calculated in the following way :

\[
\begin{align*}
\text{if } g_j(a) &\leq g_j(r^j) - p_j(r^j), & \text{then } c_j(a, r^j) = 0 \\
\text{if } g_j(r^j) - p_j(r^j) &< g_j(a) \leq g_j(r^j) - q_j(r^j), & 0 < c_j(a, r^j) \leq 1 \\
\text{if } g_j(a) &> g_j(r^j) - q_j(r^j), & \text{then } c_j(a, r^j) = 1
\end{align*}
\]

where \( p(r^j) \) and \( q(r^j) \) are the preference and the indifference thresholds for criterion and
profile respectively. These discrimination thresholds are used in order to take into account
the imprecision and/or the uncertainty of the data (criteria evaluations and decision maker's
preferences).

\[
\text{if } c_j(a, r^j) \text{ is obtained by linear interpolation : } \quad c_j(a, r^j) = \frac{p_j(r^j) - g_j(a)}{p_j(r^j) - q_j(r^j)}
\]
A global concordance index $C(a, r^i)$ for the affirmation "a is at least as good as $r^i$ for all the criteria" is then constructed in the following way:

$$C(a, r^i) = \frac{\sum_{j=1}^{n} k_j \cdot c_{j}(a, r^i)}{\sum_{j=1}^{n} k_j}$$

where $k_j$ is the weight of the criterion $j$.

The discordance index $D_j(a, r^i)$ expresses the opposition to "a is at least as good as $r^i$ on criterion $j" and is calculated in the following way:

- If $g_j(a) > g_j(r^i) - p_j(r^i)$, then $D_j(a, r^i) = 0$
- If $g_j(r^i) - v_j(r^i) < g_j(a) \leq g_j(r^i) - p_j(r^i)$, then $0 < D_j(a, r^i) \leq 2$
- If $g_j(a) \leq g_j(r^i) - v_j(r^i)$, then $D_j(a, r^i) = 1$

where $v_j(r^i)$ is the veto threshold for the criterion $j$ and the profile $r^i$.

A credibility degree $\sigma_g(a, r^i)$ for the affirmation "a outranks $r^i$" is calculated in the following way:

- If $F(a, r^i) = \{j \in F / D_j(a, r^i) > C(a, r^i)\} = \emptyset$, then $\sigma_g(a, r^i) = C(a, r^i)$
- If $F(a, r^i) \neq \emptyset$, then $\sigma_g(a, r^i) = C(a, r^i) \cdot \prod_{j \in F} \frac{1 - D_j(a, r^i)}{1 - C(a, r^i)}$

where $F$ is the set of the criteria.

This valued outranking relation $\sigma_g(a, r^i)$ is transformed into a "net" outranking relation as follows:

- If $\sigma_g(a, r^i) \geq \lambda$, then a $S r^i$

---

$^2$ $D_j(a, r^i)$ is obtained by linear interpolation: $D_j(a, r^i) = \frac{g_j(x^i) - g_j(a) - g_j(x^i)}{v_j(x^i) - p_j(x^i)}$
where $S$ represents the outranking relation and $\lambda$ ($1/2 \leq \lambda \leq 1$) is a "cut level" above which the proposition: "$a$ outranks $r^i$" is valid.

Then, preference ($P$), indifference ($I$) and incomparability ($R$) are defined in the following way:

- $a \ I \ r^i$ means $a \ S \ r^i$ and $r^i \ S \ a$
- $a \ P \ r^i$ means $a \ S \ r^i$ and not $r^i \ S \ a$
- $r^i \ P \ a$ means no $a \ S \ r^i$ and $r^i \ S \ a$
- $a \ R \ r^i$ means no $a \ S \ r^i$ and not $r^i \ S \ a$

Note that, if for a criterion $j$ the difference $g_j(a) - g_j(r^i) \ [\text{or} \ g_j(r^i) - g_j(a)]$ is superior or equal to the value of the veto threshold, then this criterion puts its veto making impossible to state $a \ S \ r^i$ (as well as $r^i \ S \ a$).

In ELECTRE TRI, there are two non total compensation procedures (the pessimistic and the optimistic one), so as to assign each alternative into one category among a set of categories defined in advance. In general, the pessimistic procedure is applied when a policy of prudence is necessary or when the available means are very constraining. While the optimistic procedure is applied for problems where the decision maker desires to favour the alternatives that present some particular interests or some exceptional qualities.
profile \( r^i \), but a majority rule combined with a mechanism of veto which justify the denial of \( r^i > a \) (cf. Roy and Bouyssou, 1993). When the value of \( \lambda \) is equal to 1 the pessimistic and
collected in the same way. This second sample was used as a holdout sample to verify the predictive ability of the models provided.

From an initial set of 18 financial ratios calculated, seven of them have been selected, to be employed in the models, using techniques such as principal components analysis, F-test, graphical representation and available financial knowledge (cf. Le Rudulier, 1994). Maybe the proper way to select the criteria would be the use of the preferences of a decision maker (financial analyst) on the available criteria. The selected financial ratios were:

\[ g_1 = \frac{\text{Gross profit}}{\text{Total assets}} \]

\[ g_2 = \frac{\text{Net income}}{\text{Total debts}} \]

\[ g_3 = \frac{\text{Current assets}}{\text{Short term debts}} \]

\[ g_4 = \frac{\text{(Current assets - Inventories)}}{\text{Short term debts}} \]

\[ g_5 = \frac{\text{Working capital}}{\text{Total assets}} \]

\[ g_6 = \frac{\text{Working capital}}{\text{Currents Assets}} \]

\[ g_7 = \frac{\text{Total debts}}{\text{Total assets}} \]

The first two criteria are profitability ratios, while the next ones are solvency ratios (liquidity, debt ratios). All the above financial ratios are to be maximized with the...
than the initial set of 18 ratios; (2) in the absence of a real decision maker (financial analyst or credit analyst), it is very difficult to express a preference for a given ratio; moreover, these ratios are considered the most important in their category (i.e. \(g_1\) and \(g_2\) are profitability ratios; \(g_3, g_4, g_5, g_6\) are liquidity ratios; \(g_7\) is debt capacity ratio). For criteria \(g_1, g_3, g_4, g_5, g_6\) the veto threshold was set at the maximum value on the criterion, because of difficulties in definition. Whatever, the conclusions about the ability of this method have to be related to the application to a particular sample for a particular period. The profile \(r^1\) and the relative thresholds are presented in Table 1. This profile has been defined based on widely accepted limits and/or the limits that came out of experience and knowledge of the financial literature. For example, for the criterion \(g_7\) (debt capacity) the value of 80% was
when a healthy firm is classified to the bankrupt group. For a decision maker the Type I error is the most severe and it should be eliminated as possible. Type II errors results to an opportunity cost for the decision maker. The error rates were calculated and they are presented in Tables 4 and 5 for the pessimistic and the optimistic procedures respectively.

Table 2: Grouping firms by pessimistic procedure

<table>
<thead>
<tr>
<th>Group</th>
<th>Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C^1$</td>
<td>a1 a2 a3 a4 a5 a6 a7 a8 a9 a10 a12 a13 a14 a15 a16 a17 a18 a19 a20 a21 a22 a23 a24 a26 a27 a28 a29 a30 a43 a48 a50 a59</td>
</tr>
<tr>
<td>$C^2$</td>
<td>a11 a25 a31 a32 a33 a34 a35 a36 a37 a38 a39 a40 a41 a42 a44 a45 a46 a47 a49 a51 a52 a53 a54 a55 a56 a57 a58 a60</td>
</tr>
</tbody>
</table>

Table 3: Grouping firms by optimistic procedure

<table>
<thead>
<tr>
<th>Group</th>
<th>Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C^1$</td>
<td>a2 a3 a4 a5 a6 a7 a9 a10 a13 a18 a19 a20 a21 a22 a23 a24 a26 a27 a28 a29 a30 a43</td>
</tr>
<tr>
<td>$C^2$</td>
<td>a1 a8 a11 a12 a14 a15 a16 a17 a25 a31 a32 a33 a34 a35 a36 a37 a38 a39 a40 a41 a42 a44 a45 a46 a47 a48 a49 a50 a51 a52 a53 a54 a55 a56 a57 a58 a59 a60</td>
</tr>
</tbody>
</table>

Table 4: Misclassification analysis of pessimistic procedure

<table>
<thead>
<tr>
<th>Type of classification</th>
<th>Number of firms</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I misclassification</td>
<td>2</td>
<td>6.67 %</td>
</tr>
<tr>
<td>Type II misclassification</td>
<td>4</td>
<td>13.33 %</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>10.00 %</td>
</tr>
</tbody>
</table>
Table 5: Misclassification analysis of optimistic procedure

<table>
<thead>
<tr>
<th>Type of classification</th>
<th>Number of firms</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I misclassification</td>
<td>9</td>
<td>30.00 %</td>
</tr>
<tr>
<td>Type II misclassification</td>
<td>1</td>
<td>3.33 %</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>16.66 %</td>
</tr>
</tbody>
</table>

In general, misclassifications provided by optimistic procedure ELECTRE TRI resulted from an overestimation of firms’ performances. A reduction in misclassification by ELECTRE TRI pessimistic procedure can be remarked. The stability analysis of the model by testing slightly different values for \( r_1 \) and the thresholds showed that these results are rather stable.

To reduce the error rates, a third category, named \( C^3 \), has been considered. In this group are classified firms for which ranking results between pessimistic and optimistic are different (those firms that, in fact, are incomparable with the profile). This group is considered as “uncertain group” and firms classified in it are considered as firms to be studied further (cf. also Zopounidis, 1987). The three classification groups of the firms presented in Tables 6 and 7 provide the relative analysis of success in classification.

Table 6: Three groups classification of firms by ELECTRE TRI

<table>
<thead>
<tr>
<th>Group</th>
<th>Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C^1 )</td>
<td>a2 a3 a4 a5 a6 a7 a9 a10 a13 a18 a19 a20 a21 a22 a23 a24 a26 a27 a28 a29 a30 a43</td>
</tr>
<tr>
<td>( C^2 )</td>
<td>a11 a25 a31 a32 a33 a34 a35 a36 a37 a38 a39 a40 a41 a42 a44 a45 a46 a47 a49 a51 a52 a53 a54 a55 a56 a57 a58 a60</td>
</tr>
<tr>
<td>( C^3 )</td>
<td>a1 a2 a3 a4 a5 a6 a7 a8 a9 a10 a11 a12 a13 a14 a15 a16 a17 a18 a19 a20 a21 a22 a23 a24 a25 a26 a27 a28 a29 a30 a31 a32 a33 a34 a35 a36 a37 a38 a39 a40 a41 a42 a43 a44 a45 a46 a47 a48 a49 a50 a51 a52 a53 a54 a55 a56 a57 a58 a59 a60</td>
</tr>
</tbody>
</table>
Table 7: Analysis of the three classification groups provided by ELECTRE TRI

<table>
<thead>
<tr>
<th>Type of classification</th>
<th>Number of firms</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct classification</td>
<td>47</td>
<td>78.33 %</td>
</tr>
<tr>
<td>Type I misclassification</td>
<td>2</td>
<td>6.67 %</td>
</tr>
<tr>
<td>Type II misclassification</td>
<td>1</td>
<td>3.33 %</td>
</tr>
<tr>
<td>Firms to be studied further</td>
<td>10</td>
<td>16.67 %</td>
</tr>
</tbody>
</table>

Although ELECTRE TRI is not a classical data analysis method, in this application we attempted to verify its discriminant power on firms data of two and three years before failure. The obtained total error rates are summarized in Table 8. There is a clear reduction to the total error rates making the three groups classification more attractive and accurate for the prediction of business failure.

Table 8: Total error of ELECTRE TRI method

<table>
<thead>
<tr>
<th>Classification</th>
<th>for year-1</th>
<th>for year-2</th>
<th>for year-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTRE TRI pessimistic</td>
<td>10.00 %</td>
<td>21.67 %</td>
<td>23.33 %</td>
</tr>
<tr>
<td>ELECTRE TRI optimistic</td>
<td>16.67 %</td>
<td>21.67 %</td>
<td>21.67 %</td>
</tr>
<tr>
<td>ELECTRE TRI (3 categories)</td>
<td>5.00 %</td>
<td>6.67 %</td>
<td>6.67 %</td>
</tr>
</tbody>
</table>

To test the predictive ability of the model the ELECTRE TRI method was also applied to the holdout sample. The classification accuracy provided is presented in Table 9.
Table 9: Misclassification of ELECTRE TRI grouping on the holdout sample

<table>
<thead>
<tr>
<th>Type of classification</th>
<th>Number of firms</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>correct classification</td>
<td>17</td>
<td>70.83 %</td>
</tr>
<tr>
<td>misclassification Type I</td>
<td>0</td>
<td>0.00 %</td>
</tr>
<tr>
<td>misclassification Type II</td>
<td>1</td>
<td>8.33 %</td>
</tr>
<tr>
<td>firms to be studied further</td>
<td>6</td>
<td>25.00 %</td>
</tr>
</tbody>
</table>

It is important to note that the percentage of misclassifications is approximately the same as the one obtained with the first sample. On the other hand the percentage of firms to be studied further increased slightly. This fact is natural and somehow expected because the method is applied on a new “unknown” sample of firms. The results show that the preferential model is a quite general model for the assessment of failure risk for firms under the same properties as those defined previously and the multicriteria methodology seems to be able to be used for bankruptcy prediction in Greece.

3.3. Comparison between ELECTRE TRI and Discriminant Analysis

The philosophy of the multicriteria method ELECTRE TRI is much different than the one of DA which is a statistical method. ELECTRE TRI works in real time, interacts with the decision maker incorporating his judgements in the model and helps the decision maker to learn about his preferences (see Roy and Bouyssou, 1993). Although DA is much different than ELECTRE TRI, just for comparison reasons a discriminant analysis model was constructed on the data of the basic sample one year prior to bankruptcy, using the 7 ratios selected previously. This model was applied on the data of the two and three years prior to actual failure. Table 10 shows the misclassification analysis of the DA model.
Table 10: Grouping of firms by Discriminant Analysis

<table>
<thead>
<tr>
<th></th>
<th>year-1</th>
<th>year-2</th>
<th>year-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Misclassification type I</td>
<td>33.33 %</td>
<td>46.66 %</td>
<td>43.33 %</td>
</tr>
<tr>
<td>Misclassification type II</td>
<td>3.33 %</td>
<td>3.33 %</td>
<td>6.66 %</td>
</tr>
<tr>
<td>Total misclassification</td>
<td>18.33 %</td>
<td>25.00 %</td>
<td>25.00 %</td>
</tr>
</tbody>
</table>

By considering the ELECTRE TRI model results (Table 8) and by comparing it with DA, we can remark that the ELECTRE TRI method gives much better results, particularly for year-2 and year-3. Moreover, most of the firms misclassified by DA are proposed to be studied further by ELECTRE TRI. As a matter of fact, discriminant analysis does not have the possibility to propose a further study for uncertain firms, and is obliged to classify those firms in one of the two categories, increasing the misclassifications.

The ELECTRE TRI model is able to predict the bankruptcy of a firm with a low percentage of error, even three years before it will happen. Of course, the percentage of uncertain firms is important when we are far from the reference year (year of actual failure).

4. CONCLUDING REMARKS

In this study, the multicriteria decision aid method ELECTRE TRI, is proposed for the prediction of business failure in Greece. This method, especially conceived for sorting out problems, adapts well to the problem of failure prediction.

The results of the application on a sample of industrial Greek firms confirm the ability of the method to classify the firms in three classes of risk (failure / non failure / uncertain), providing a satisfactory degree of accuracy.

Compared to other previous methods, ELECTRE TRI has several advantages:

1. It accepts incomparability, providing an important information to the decision maker for
3. It can contribute in the minimization of the time and costs of the decision making process 
   (ELECTRE TRI is an information processing system in real time);

4. It offers transparency in the firms' grouping, allowing for argument in the decisions.

5. It takes into account the preferences of the decision-maker (cf. Malecot, 1986).

The approach with DA is totally different than the ELECTRE TRI. With DA, 
the model is constructed once and it is used without any changes, while with ELECTRE 
TRI, the model is constructed taking into account the preferences of the decision maker and 
it can be modified in real time if the preferences of the decision-maker change or if new 
information is provided by the environment. Finally, ELECTRE TRI can be considered to be 
an effective operational tool for the prediction of business failure. It can be incorporated in 
the models' base of multicriteria decision support systems as those proposed by Siskos et al. 
(1994) and Zopounidis et al. (1992) and Zopounidis et al. (1995).
REFERENCES


