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A MULTICRITERIA APPROACH FOR THE ANALYSIS AND PREDICTION OF BUSINESS FAILURE IN GREECE [1]

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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.

Since the study of Altman in 1968, several studies proposing other multivariate methods have been used to overcome the disadvantages of the method and to provide higher prediction accuracy. Starting from different views and requirements researchers proposed more sophisticated methods, sometimes already applied to other scientific fields. Among these studies, there are the study of Ohlson (1980) using logit analysis and the study of Zmijewski (1984) using probit analysis. Frydman et al. (1985) first employed the recursive partitioning algorithm to the business failure problem. Mathematical programming methods were used by Gupta et al. (1990). Other methods used were survival analysis by Luoma and Laitinen (1991), expert systems by Messier and Hansen (1988) and neural networks by Altman et al. (1994).

Most of the methods proposed have already been overviewed in the past years, for examination and comparison purposes in some review articles presented. Such reviews were these of Vernimmen's (1978) examining failure models and criticizing their contribution and limits and Scott's (1981) investigating empirical models developed and bankruptcy theories presented mainly on USA studies. Zavgren (1983) surveyed different methods and empirical models proposed for the prediction of corporate failure in USA. Altman in 1984 presented a review of models developed in several countries, Jones (1987) examined the techniques used

for bankruptcy prediction in USA and Keasey and Watson (1991) explored the limitations and usefulness of methods used for the prediction of firm financial distress. Zopounidis and Dimitras (1993) and Zopounidis (1995) gave a complete review of methods used for the prediction of business failure and of new trends in this area.

However, not only new methods but also new problems affecting the variables involved have surfaced. Up to now, most of the proposed models contain only quantitative variables (financial ratios). But prediction of business failure is also affected by variables of a qualitative character such as quality of management, market trend, market share, social importance, etc. The importance of qualitative variables has been mentioned in several studies like those of Alves (1978), Zopounidis (1987), etc.

To incorporate qualitative variables in the evaluation of business failure risk, multicriteria decision aid methods have been proposed by Andenmatten (1995), Dimitras et. al. (1995), Mareschal and Brans (1991), Zollinger (1982) and Zopounidis (1987). In addition, these methods allow the decision maker to interact expressing his preferences and past experiences in the building of the failure risk model. The aim of this study is to test the ability of the multicriteria decision aid method ELECTRE TRI, presented by Yu (1992) in predicting business failure, and to compare it with discriminant analysis. Section 2 presents the basic concepts of ELECTRE TRI method. The application of ELECTRE TRI on a sample of Greek firms and the comparison of its results with those obtained with discriminant analysis are presented in section 3. In the concluding remarks, the merits of the proposed multicriteria method are discussed and possible new trends in the field of business failure analysis are given.

2. THE ELECTRE TRI METHOD

The ELECTRE TRI method belongs to the ELECTRE family of multicriteria methods (Roy, 1991). The particularity of the ELECTRE family (and of the French school) is to refuse the possibility of total compensation between the alternatives performances on the criteria, and then to accept incomparability and intransitivity.

ELECTRE TRI is a multicriteria method specially conceived for sorting problems. Other multicriteria methods conceived for sorting problems have been presented by Massaglia and Ostanello (1991), Roy (1981) and Roy and Moscarola (1977). From a finite

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 $\mathbf{C^i}$, i = 1,..., k, where C^1 is the worst category and C^k the best one. We can also define the profiles $\mathbf{r^i}$, i = 1, ..., k-1, where r^1 is the lower profile and r^{k-1} the upper. Then the profile r^i 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 $\mathbf{r^i}$, the concordance index $\mathbf{c_j(a,r^i)}$ expresses the strength of the affirmation "alternative **a** is at least as good as profile $\mathbf{r^i}$ on criterion **j**", and for an increasing criterion **j** is calculated in the following way :

$$\begin{aligned}
&\text{if } g_j(a) \le g_j(r^i)-p_j(r^i), && \text{then} \quad c_j(a,r^i) = 0\\
&\text{if } g_j(r^i) - p_j(r^i) < g_j(a) \le g_j(r^i)-q_j(r^i), && \text{then} \quad 0 < c_j(a,r^i) \le 1 \quad [1]\\
&\text{if } g_j(a) > g_j(r^i)-q_j(r^i), && \text{then} \quad c_j(a,r^i) = 1
\end{aligned}$$

where $\mathbf{p(r^i)}$ and $\mathbf{q(r^i)}$ 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).

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[1] $\mathbf{c_j(a,r^i)}$ is obtained by linear interpolation : $$c_j(a,r^i) = \frac{p_j(r^i) - \left[g_j(r^i) - g_j(a)\right]}{p_j(r^i) - q_j(r^i)}$$

A global concordance index $\mathbf{C(a,r^i)}$ for the affirmation "**a** is at least as good as $\mathbf{r^i}$ 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 $\mathbf{k_j}$ is the weight of the criterion j.

The discordance index $\mathbf{D_j(a,r^i)}$ expresses the opposition to "**a** is at least as good as $\mathbf{r^i}$ 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 $0 < D_j(a,r^i) \leq 1$ [2]

if $g_j(a) \leq g_j(r^i)-v_j(r^i)$, then $D_j(a,r^i) = 1$

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

A credibility degree $\sigma_S(\mathbf{a,r^i})$ for the affirmation "**a** outranks $\mathbf{r^i}$," is calculated in the following way:

$$\text{if } F(a,r^i) = \{ j \in F / D_j(a,r^i) > C(a,r^i) \} = \emptyset, \ \sigma_S(a,r^i) = C(a,r^i)$$

$$\text{if } F(a,r^i) \neq \emptyset, \text{ then } \sigma_S(a,r^i) = C(a,r^i) \cdot \prod_{j \in F} \frac{1-D_j(a,r^i)}{1-C(a,r^i)}$$

where F is the set of the criteria.

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

$$\text{if } \sigma_S(\mathbf{a,r^i}) \geq \lambda, \text{ then a } \mathbf{S}\, r^i,$$

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[2] $\mathbf{D_j(a,r^i)}$ is obtained by linear interpolation : $D_j(a,r^i) = \frac{g_j(r^i) - g_j(a) - g_j(r^i)}{v_j(r^i) - p_j(r^i)}$

where **S** represents the outranking relation and λ ($1/2 \leq \lambda \leq 1$) 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 $g_j(a)-g_j(r^i)$ [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.

In the sorting procedure, firm **a** is compared first to the worst profile r^1 and in the case where a **P** r^1 , a is compared to the second profile r^2, etc., until one of the following situations appears :

- if a **P** r^i and r^{i+1} **P** a or a **I** r^{i+1}, then a is assigned to category i+1 for both pessimistic and optimistic procedures,
- if a **P** r^i and a **R** r^{i+1}, a **R** r^{i+2},..., a **R** r^{i+k}, r^{i+k+1} **P** a, then a is assigned to category i+1 with pessimistic procedure and to category i+k+1 with optimistic procedure.

When the value of λ gradually decreases the pessimistic procedure becomes less constrained than the conjunctive procedure. In this case, it is not necessary that all criteria outrank the profile r^i, but one is satisfied when the majority of criteria outrank this profile. In a similar way, the optimistic procedure becomes more relaxed than the disjunctive procedure. In this case, for an assignement, it is necessary to have not only one criterion which outranks the

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 λ is equal to 1 the pessimistic and optimistic procedures are identical with conjunctive and disjunctive procedures respectively.

ELECTRE TRI manages incomparability in such a way that it will point out the alternatives that have particularities in their evaluations. In cases where some alternatives are incomparable with one or more reference profiles then they are assigned to different categories by optimistic and pessimistic procedures. This is due to the fact that these alternatives have good values for some criteria and, simultaneously, bad values for other criteria ; moreover these particular alternatives must be examined with attention. In this way the notion of incomparability included in the ELECTRE TRI method brings an important information to the decision maker.

3. APPLICATION

In this section, we describe first the sample and data of the study and, then, the obtained results.

3.1. Sample and data

The sample of firms consisted of 60 industrial firms, named by a1, a2, ..., a60. Firms from a1 to a30 were bankrupted according to the Greek law during years 1985 to 1990. Although the year of bankruptcy is not common for all firms in the sample, they are all considered to be failed in the "zero" year, taken as year of reference. The healthy firms (firms from a31 to a60) were matched to the failed ones according to industry and size (measured by total assets and number of employees). Therefore, two categories were defined to receive these firms :

C^1 : High risk group (failed firms) and

C^2 : Low risk group (non failed or healthy firms).

For each firm data from the balance sheet and income statement were collected for the three years prior to actual failure of the bankrupted firms. No qualitative characteristics were employed because of problems in the collection of them for bankrupted firms in Greece. This sample is considered as an estimation sample. A second sample of 24 firms was

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:

g1 = Gross profit / Total assets

g2 = Net income / Total debts

g3 = Current assets / Short term debts

g4 = (Current assets - Inventories) / Short term debts

g5 = Working capital / Total assets

g6 = Working capital / Currents Assets

g7 = Total debts / 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 exception of **g7** which is to be minimized. This means that the lower the value of **g7** the greater the performance of the firm on this ratio and subsequently the greater chance has the firm to be ranked in the low risk group (category C^2).

3.2. Results

For the application of ELECTRE TRI[3] the profile and the relative thresholds of preference (p), indifference (q) and veto (v) on each criterion were defined by the graphical representation and the previous experience and financial knowledge. The weights (k) for the criteria were taken all equal to 1 for two principal reasons : (1) The seven criteria (g_1, ... g7) were derived by the principal compenent analysis and are regarded as more important

[3]The authors are indebted to Professor B. Roy for providing the ELECTRE TRI software.

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 **g1, g3, g4, g5, g6** 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 determined. For the Greek case, firms with a capacity of debt less than this value are considered to be rather "good". In other case, firms with a capacity of debt superior to this limit are rather "bad". The thresholds are used in order to take into account the imprecision and/or the uncertainty of the data (criteria's evaluations and decision maker's preferences). At this level of analysis, it is necessary to remark that the values of the profile r^1 and the values of the thresholds were also determined by "interactive" use of the software ELECTRE TRI, in order to minimize the "false" assignements. Thus, one observes the dynamic character of the method in the assessment of the sorting model.

Table 1: Profile r^1 and relative thresholds

Criteria	**g1**	**g2**	**g3**	**g4**	**g5**	**g6**	**g7**
Profile	20	1	100	60	5	30	80
k	1	1	1	1	1	1	1
q	1	0.05	5	3	0.25	1	1
p	2	0.1	10	6	0.5	3	2
v	max	1	max	max	max	max	15

Setting λ to the value 0.67, the resulted grouping of firms for the optimistic and the pessimistic procedures are presented in the Tables 2 and 3 respectively, where the misclassified firms are in bold. There exist two types of errors: Type I and Type II. The Type I error occurs when a failed firm is classified as healthy while Type II error occurs

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

Group	Firms
C^1	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***
C^2	***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

Table 3: Grouping firms by optimistic procedure

Group	Firms
C^1	a2 a3 a4 a5 a6 a7 a9 a10 a13 a18 a19 a20 a21 a22 a23 a24 a26 a27 a28 a29 a30 ***a43***
C^2	***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

Table 4: Misclassification analysis of pessimistic procedure

Type of classification	Number of firms	Percentage (%)
Type I misclassification	2	6.67 %
Type II misclassification	4	13.33 %
Total	6	10.00 %

Table 5: Misclassification analysis of optimistic procedure

Type of classification	Number of firms	Percentage (%)
Type I misclassification	9	30.00 %
Type II misclassification	1	3.33 %
Total	10	16.66 %

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

Group	Firms
C^1	a2 a3 a4 a5 a6 a7 a9 a10 a13 a18 a19 a20 a21 a22 a23 a24 a26 a27 a28 a29 a30 ***a43***
C^2	***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
C^3	a1 a8 a12 a14 a15 a16 a17 a48 a50 a59

Table 7: Analysis of the three classification groups provided by ELECTRE TRI

Type of classification	Number of firms	Percentage (%)
Correct classification	47	78.33 %
Type I misclassification	2	6.67 %
Type II misclassification	1	3.33 %
Firms to be studied further	10	16.67 %

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

Classification	for year-1	for year-2	for year-3
ELECTRE TRI pessimistic	10.00 %	21.67 %	23.33 %
ELECTRE TRI optimistic	16.67 %	21.67 %	21.67 %
ELECTRE TRI (3 categories)	5.00 %	6.67 %	6.67 %

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

Type of classification	Number of firms	Percentage (%)
correct classification	17	70.83 %
misclassification Type I	0	0.00 %
misclassification Type II	1	8.33 %
firms to be studied further	6	25,00 %

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

	year-1	year-2	year-3
Misclassification type I	33.33 %	46.66 %	43.33 %
Misclassification type II	3.33 %	3.33 %	6.66 %
Total misclassification	18.33 %	25.00 %	25.00 %

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 the uncertainty in the classification of some firms;
2. It accepts qualitative criteria (cf. Dimitras et al., 1995);

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).

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