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THE USE OF DISCRIMINANT ANALYSIS IN THE ASSESSMENT OF MUNICIPAL COMPANY'S FINANCIAL HEALTH

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ABSTRACT. Decentralization processes in the CEE countries have stimulated the search for measures of financial health of municipal companies that would be comparable and understandable to a broad range of stakeholders. In this study, we have developed a five-factor discriminant model for assessing municipal company's financial health (M-Score model) using data on 50 Ukrainian companies during 2014-2017. The final test sample consisted of 71 companies operating in Bulgaria, Croatia, Czech Republic, Poland, Romania and Ukraine. Our findings can be summarized as follows. First, the empirical model suggests that the equity-assets ratio, the current ratio, and the average accounts receivable turnover have both the highest discriminatory power and the greatest impact on the municipal company's financial health. Secondly, we provide convincing evidence that the municipal company's financial health does not depend on the region, but on the nature of its activity and the purpose of enterprise activity. In particular, water and energy utilities are generally financially unhealthy, and out of 45 so-called necessary enterprises, only 12 are classified as financially healthy. The company's M-Score will help managers, lenders, investors, local authorities, and the public to answer the following questions: Can the company avoid financial default? What is its position at the local level? What is its place in the industry?

***JEL Classification*:** J23, E24, B59

Keywords: municipal company, financial health, multiple discriminant model, M-Score, CEE countries.

1. Introduction

The processes of decentralisation in the post-socialist countries of Central and Eastern Europe (CEE countries) are uneven and local governments face a wide range of issues. But the common question for all, which is constantly on the agenda, is ensuring the life of a city or a territorial community. Municipal companies ensure daily life of the city as an integral system, therefore, both people's comfort and financial and budgetary interests of the city as an owner depend on their financial health. Municipal companies are enterprises owned by local governments, and this a priori provides greater transparency and democratic control over their activities as compared to commercial enterprises. However, for public monitoring, including with media involvement, understandable and comparable measures of municipal company's financial health are needed. On the other hand, instruments for comparative evaluation of financial health are required by regulators to identify those utilities that can be provided with access to subsidized capital, as well as investors for identifying financially sound enterprises and tracking the effectiveness of investments.

Currently, however, to assess the financial health of municipal companies, traditional ratio analysis is used, as a rule. However, the ratio analysis, due to its essentially univariate nature, cannot provide unambiguous information. For instance, a company with a poor profitability and/or solvency record may be regarded as a potential bankrupt. But, because of its above average liquidity, the situation may not be considered that serious (Altman, 2013). Therefore, several indicators should be combined into a meaningful predictive model.

These pressing issues have stimulated both operational and scientific search for measures to assess financial health and methods to predict financial defaults of municipal companies. It is important to note that today municipalities are forced to deal with issues of climate and energy. In this context, water and energy utilities are the most vulnerable ones. However, this problem is neither new, nor region-specific. The issues of default and bankruptcy of water utilities were first investigated in the United States back in the 1990s. Beecher et al. (1992) developed a distress classification model for water utilities. The authors proposed the Distress score as the sum of seven financial ratios (Beecher et al., 1992, p. 157) and empirically developed a generalized evaluation system, whereby water utilities can be classified as follows: good to excellent, weak to marginal, distress. Jordan (1998) also used the ratio analysis and identified financial health of the water utility as follows: Financial Health = f (Size of Liquid Assets, Cash-flow, Debt, Expenditures). Applying factor analysis to the data obtained from water utilities in Georgia (the USA), he selected most significant coefficients to represent the variables of this model: return on assets, current ratio, debt-to-equity ratio, operating ratio, and cash flow coverage. These papers are extremely useful for our study. Wirick et al. (1997) proposed a ratio analysis and a discounted cash flow model for evaluation of water utility financial capacity, a model that treats the entire utility as an investment problem; this approach is appropriate because of the capital-intensive nature of water utilities in the United States in particular. Wibowo and Alfen (2015) developed a logistic regression model to predict the probability that Indonesian water utilities would default on their payments to the central government; the authors used two indicators (financial strength and technical efficiency), based on linear combinations of known financial ratios.

As for other types of municipal companies, we should mention the following studies. Cruz and Marques (2011) investigated the viability of a new model of the municipal company in the provision of urban infrastructure services in Portugal using three methodological approaches: (i) a questionnaire, (ii) a SWOT-analysis, and (iii) the index number theory. Alsaied (2017) used statistical modelling to determine the performance indicators of municipal electric utilities that are needed by city governments to better track their capital expenditures and investments. Romanova (2012) has developed a four-factor discriminant model that takes into account the specifics of the enterprises of housing and communal services. In our study, we will partially use the results of this paper. Finally, we would like to note the methodology offered in (Kicina, 2017) for assessment of financial health of state-owned and municipality-owned companies that was created within the initiative “Promoting transparency and financial sustainability of regional policies, state-owned enterprises and local authorities in Moldova”. The authors offer a basic set of 10 financial indicators to calculate the overall rating of the financial health of companies, as well as to set the benchmark and enable international comparison of companies.

Also, many studies have focused on the financial health of municipalities. For example, Cabaleiro et al. (2013) developed a method for assessing municipal financial health, which combines multivariate statistical techniques of principal component analysis and discriminant analysis. Matejova et al. (2014) established the relationship between economic indicators and the municipality size in Czech Republic, the so-called economies of scale, using econometrics methods.

Thus, different methods and systems of coefficients have been already proposed for assessing financial health of municipal companies. But only the discriminant model (score) is both a measure of assessment and a tool for comparative analysis of the financial health of municipal enterprises. As it is well known, multiple discriminant analysis for prediction of corporate bankruptcy was first applied by Altman (1968). He used the sample of 66 firms to develop a five-variable discriminant function (Altman, 1968, p. 294), the so-called Z-Score, which best discriminates between companies in two mutually exclusive groups: bankrupt and non-bankrupt firms. The model had good performance, but, as Beecher et al. (1992, p. 258) correctly noted, "because of structural and operating differences, the Altman's Z-Score model is not expected to perform well for water companies". Later, the model was adapted for non-manufacturers and emerging markets as an EM Score (Altman & Hotchkiss, 2006, p. 267). Obviously, there is a need for a discriminant model for municipal companies outside the United States.

The purpose of this study is to develop a multiple discriminant model for assessment and comparative analysis of the financial health of municipal companies in CEE countries. In addition, we use the estimated model to test the hypothesis: The municipal company's financial health depends not on the region (city, community, country), but on the nature of its activity and the purposes of this activity. In this study, we develop a discriminant model on the basis an initial training sample of 50 Ukrainian healthy and unhealthy municipal companies; to test the predictive performance of the estimated model, we use a test sample of 71 municipal companies from Bulgaria, Croatia, Czech Republic, Poland, Romania, and Ukraine. The annual financial statements of municipal companies were collected from the official websites of companies and municipalities. However, some reservations regarding the size of the training sample should be made immediately: (i) financial statements of municipal companies for the years 2014-2017 are not publicly available, despite the requirements for transparency in all CEE countries; (ii) verification of discriminant analysis assumptions also led to the rejection of many municipal companies. Nevertheless, we have obtained a five-factor discriminant model (M-Score model) with high discriminant power and classification accuracy that showed a number of significant and intuitively reasonable effects to aid managers of such companies and local authorities. In particular, we have found that the equity-assets ratio, the current ratio and the average accounts receivable turnover have both the greatest discriminatory power and the greatest impact on financial health of municipal enterprises. Our other significant empirical finding is that in CEE countries, regardless of the city (community), water and energy enterprises are generally financially unhealthy. The remainder of the paper is organized as follows. Section 1 presents our methodology. In Section 2, we describe the procedures for developing a model and prove its discriminatory power and classification accuracy, and then discuss the predicted results. In the final section, we discuss the conclusions drawn from this study and identify directions for future research.

2. Methodology

In order to develop a technique for assessing the municipal company's financial health, we have chosen multiple discriminant analysis and ratio analysis. Multiple discriminant analysis (MDA) is a statistical technique used to classify an observation into one of several a priori groupings dependent upon the observation's individual characteristics (Altman & Hotchkiss, 2006, p. 239). Therefore, the first step is to establish explicit group classifications; the number of original groups can be two or more. In our analysis, the initial sample, the so-called training sample, will consist of two groups of municipal companies. The first one is formed by the financial healthy companies and the other consists of unhealthy companies. We used the ratio analysis to classify enterprises.

The purpose of the discriminant analysis is to construct a function as a linear combination of independent variables that best discriminates between healthy and unhealthy companies. The linear discriminant function is written as: $f(x) = \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p$, where x_j is independent discriminant variable; β_j is unknown discriminant coefficient (j = 1, 2, …, p). Before evaluating the discriminant coefficients, it is necessary to test the discriminant analysis assumptions that are discussed by many researchers (see, e.g., Tabachnick & Fidell, 1989; Rencher, 2002; Mihalovic, 2016). Assumptions that accompany the discriminant function and tests are as follows: equal sample sizes and complete data, multivariate normality within groups, the absence of outliers, homogeneous within-group variance, linearity among all pairs of variables, no multicollinearity.

The most discussed issue of discriminant analysis is the multivariate normality within groups and the absence of outliers. In this study, we use the Hampel test to detect outliers as follows. The Hampel test identifies the i-th observation of the data series x_{ij} as an outlier, when

$$|x_{ij} - Md(x_j)| > 5.2\ MAD, \tag{1}$$

where $Md(x_j)$ is the median of a data set x_j, and $MAD = Md(|x_{ij} - Md(x_j)|)$ is the median absolute deviation ($i=1, 2, \ldots, n_k; j=1, 2, \ldots, p$), nk is the size of the k-th subsample (group) with $n_1+n_2=N$, and $n_1=n_2$, when the condition of equality of the subsamples is met.

Estimation of the discriminant function, testing of statistical significance and predicative accuracy will be carried out using approaches that are described by Altman (1968), Rencher (2002), and Mihalovic (2016). To estimate the discriminant coefficients, one should proceed from the fact that for the companies under consideration the between-groups variation SS_b (explained variation) should be maximum, and the within-groups variation SS_W (unexplained variation) should be minimal. Thus, if the ratio

$$\lambda = \frac{SS_b}{SS_w} = \frac{\sum_{k=1}^{2} n_k (\bar{y}_k - \bar{y})^2}{\sum_{k=1}^{2} \sum_{i=1}^{n_k} (y_{ik} - \bar{y}_k)^2} \to \max, \tag{2}$$

where $\bar{y}_k = \bar{f}_k(x)$ is the group mean, and $\bar{y}$ is the overall sample mean is maximized, we achieve the best separation of groups (Altman, 1968, p. 598).

Using matrix notation, the ratio λ (called the discriminant criterion) can be written as follows:

$$\lambda = \frac{\left(\beta^T (M_1 - M_2)\right)^2}{\beta^T S_{pl} \beta} \to \max, \tag{3}$$

where M_k is the mean vector in group k, and S_{pl} is the pooled covariance matrix, which is defined by formula

$$S_{pl} = \frac{1}{n_1 + n_2 - 2} \cdot \left(X_1^T X_1 + X_2^T X_2\right), \tag{4}$$

where X_k is the matrix of deviations of observed values from mean in group k (k = 1, 2).

The maximum of λ ratio occurs when

$$\beta = (S_{pl})^{-1} \cdot (M_1 - M_2), \tag{5}$$

where $(S_{pl})^{-1}$ is the inverse matrix.

Finally, the discriminant constant is calculated as the mean of the discriminant functions of the companies of each group. Graphically, the linear equation $\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p = c$ defines the hyperplane that separates the points assigned to healthy companies from the points assigned to unhealthy companies.

After evaluating the discriminant function the level of significance must be assessed. We will use the measure of Wilks' lambda that evaluates the statistical significance of discriminatory power of the discriminant function. Wilks' Λ is calculated as the ratio of the unexplained variation to the total variation $\Lambda = SS_W / (SS_b + SS_W)$, i.e., $\Lambda = 1 / (1 + \lambda)$.

The Wilks' Λ-test is used to test the hypothesis H_0: $\mu_1 = \mu_2$ (the groups are not different from each other) vs. H_1: $\mu_1 \neq \mu_2$ (there are different groups). Similarly, we carry out a multivariate test of discriminatory power of the variables x_j. The parameters in Wilks' Λ distribution are p is the number of variables, $v_H = k - 1$ is the number of degrees of freedom for hypothesis, and $v_E = k(N - 1)$ is the number of degrees of freedom for error. Since for two groups $v_H = 1$ (p is any), according to Runcher (2002, p. 163), the Wilks' Λ is transformed to an exact statistic having F-distribution as follows:

$$F = \frac{1-\Lambda}{\Lambda} \cdot \frac{\nu_E - p + 1}{p}. \tag{6}$$

The hypothesis H_0 is rejected when F exceeds the upper α-level percentage point of the F-distribution, with degrees of freedom $df_1 = p$, $df_2 = v_E - p + 1$.

Another way to estimate the real utility of the discriminant function can be obtained by considering the of canonical correlation coefficient r_c, which is a measure of the relationship between groups and the discriminant function. Since the canonical correlation coefficient is defined as $r_c = [SS_b / (SS_b + SS_W)]^{1/2}$, the canonical correlation is related to λ by the following formula $r_c = [\lambda / (1+\lambda)]^{1/2}$.

In order to evaluate the performance of the estimated discriminant model, Altman (1968, p. 599) proposed a classification chart or an "accuracy-matrix". Table 1 shows how the accuracy matrix is formed in our analysis. The actual group memberships is equivalent to the a priori grouping (by definition of the financial health of a municipal company in dynamics) and the model attempts to classify correctly these companies. At this stage, the model is explanatory; but when new companies are classified, the model is predictive. Cells H, like in the Altman accuracy matrix, are designed for correct classifications (Hits) and M for misses (Misses). As we predict the company's financial health, $M_1/(H_1+M_1)$ per cent is a Type I error and $M_2/(H_2+M_2)$ per cent is a Type II error. The percentage of correct classifications or the Hit Ratio $HR = (H_1+H_2)/N$ is a statistical measure that's used to assess the goodness of fit of the discriminant model, i.e., this is an analogue of the coefficient of multiple determination (R-squared) in the regression analysis.

Table 1. Accuracy matrix

Actual group membership	Predicted group membership			Type error	Per cent correct	Per cent error
	Unhealthy	Healthy	Total			
Financially unhealthy companies	H_1	M_1	H_1+M_1	Type I	$H_1/(H_1+M_1)$	$M_1/(H_1+M_1)$
Financially healthy companies	M_2	H_2	H_2+M_2	Type II	$H_2/(H_2+M_2)$	$M_2/(H_2+M_2)$
Total	H_1+M_2	H_2+M_1	N	Total	$(H_1+H_2)/N$	$(M_1+M_2)/N$

Source: own compilation.

Finally, if the discriminant model is statistically significant and the classification accuracy is acceptable, the focus is on conducting meaningful interpretations of the results.

3. Empirical results and discussion

3.1. The data

The discriminant model is based on the annual financial statements of municipal companies, namely: (i) the balance sheet and (ii) the profit and loss statement. Since for an a priori grouping of companies, it is necessary to investigate the change in financial health indicators for several years, the training sample covers the period 2014-2017. As for the data set, the annual financial statements of municipal companies are collected from official websites of companies and municipalities, and then five data sets were constructed (financial ratios, which we will justify below). Subsequent testing of discriminant analysis assumptions led to the rejection of many municipal companies. However, after testing the discriminant analysis assumptions, many companies had to be disregarded. Moreover, most companies had to be ignored due to incomplete or unavailable data, despite the demands for transparency in all CEE countries. Therefore, the final training sample consisted of 50 municipal companies in 16 Ukrainian cities, which belong to different categories based on the nature of the activity: utility enterprises, transportation enterprises, environmental enterprises, facility enterprises, community development, recreation enterprises, public safety enterprises, and miscellaneous.

In addition, to test the predictive performance of the model, we used the 2016 and 2017 annual financial statements of municipal enterprises of five more CEE countries. The final test sample included 71 municipal companies (50 companies from Ukraine, 7 from the Czech Republic, 6 from Romania, 3 from Bulgaria, 3 from Croatia, and 2 from Poland). This choice is due to the need to test both the predictive performance of the evaluated model and the research hypothesis, i.e., CEE countries should be comparable, but with different levels of development. According to the World Bank Income Group Classification, selected CEE countries are in different income groups, but the Global Innovation Index does not differ significantly, namely: the Czech Republic (Score is 48.75) and Poland (41.67) are high income economies, Bulgaria (42.65), Croatia (40.73), and Romania (37.59) are upper-middle income economies, and Ukraine (38.52) is lower-middle income economy (Cornell University et al., 2018).

3.2. Development and testing of the M-Score model

In order to classify enterprises, we defined financial health as follows: *Municipal company's financial health* = *f* (*Liquidity*, *Financial sustainability*, *Solvency*, *Profitability*, *Efficiency*). We partly use the approach of Jordan (1998) because is no legal definition of the company's financial health. Next, for each of the five categories, we selected one significant ratio, taking into account the specifics of municipal companies, namely: (1) Absolute Liquid Ratio, (2) Working Capital to Current Assets Ratio, (3) Debt to Equity Ratio, (4) Return on Equity, (5) Current Asset Turnover Ratio. We chose these ratios since they are significant in their categories and have numerical values of the recommended ranges. For an unambiguous interpretation of the selected ratios, the calculated formulas and recommended ranges for municipal companies are shown in Table 2.

Table 2. Municipal company's financial health: categories, ratios, definitions, and ranges

Category	Ratio	Definition	Rang
Liquidity	Absolute liquid ratio	Short-term financial assets / Current liabilities	.2 and over*
Financial sustainability	Working capital to current assets ratio	(Equity – Noncurrent assets) / Current assets	.3 and over*
Solvency	Debt to equity ratio	Liabilities / Equity	2:1 – 3:1**
Profitability	Return on equity	Net Profit (Loss) / Equity	.15 and over**
Efficiency	Current asset turnover ratio	Net sales / Average current assets	3 and over***

Note: * Lihonenko et al. (2005), ** Jordan (1998), *** Vasina (2012).
Source: own compilation.

The identification of the municipal company's financial health is as follows. If the ratio value belongs to the recommended interval, it is assigned the value 1, otherwise 0. If the total sum is 3 and over, the company is financially healthy this year. To finally classify the company, these ratios should be charted over time since the trend is more important than one year's data. A constant trend points to good financial performance preferred to high numbers one year followed by erratic movements over time (Jordan, 1998, p. 13). Therefore, we considered the change in these financial ratios for 2014-2016 and referred the company to a group of financially healthy if the sum of points for three years is 2 or 3; otherwise. the company was referred to a group of financially unhealthy. It should be noted that in this case, we are talking about conditionally healthy companies. Such a soft approach to the classification of financially healthy companies is explained by an attempt to satisfy the condition of equality of subsamples. The point is that the category "utility enterprises" includes all public utilities and contains the largest number of companies in any country; at least one utility is available in every city (e.g., electric, gas, water, and sewerage). But utilities, as a rule, are not financially healthy. Since utilities require significant infrastructure, they often carry large amounts of debt (Klinefelter & Klinefelter, 2015). Thus, as a result of the analysis, we received two subsamples of 25 conditionally healthy and 25 unhealthy companies for 2015.

After the initial groups are defined, we have chosen the variables of the discriminant function, which best identify the municipal company's financial health and satisfy the assumptions of discriminant analysis. At the same time, we considered the variables of the Altman model for nonmanufacturers and emerging markets (Altman & Hotchkiss, 2006), as well as the variables of the Romanova model for utilities (Romanova, 2012). Finally, five key variables were selected as doing the best overall job together in the prediction of the municipal company's financial health; the five-variable discriminant function is of the form:

$$f(x) = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5, \quad (7)$$

where x_1 = Current assets / Current liabilities, x_2 = Equity / Total assets, x_3 = Net sales / Property, plant and equipment (average), x_4 = Gross profit / Net sales, and x_5 = Average accounts receivable / (Net sales / 365).

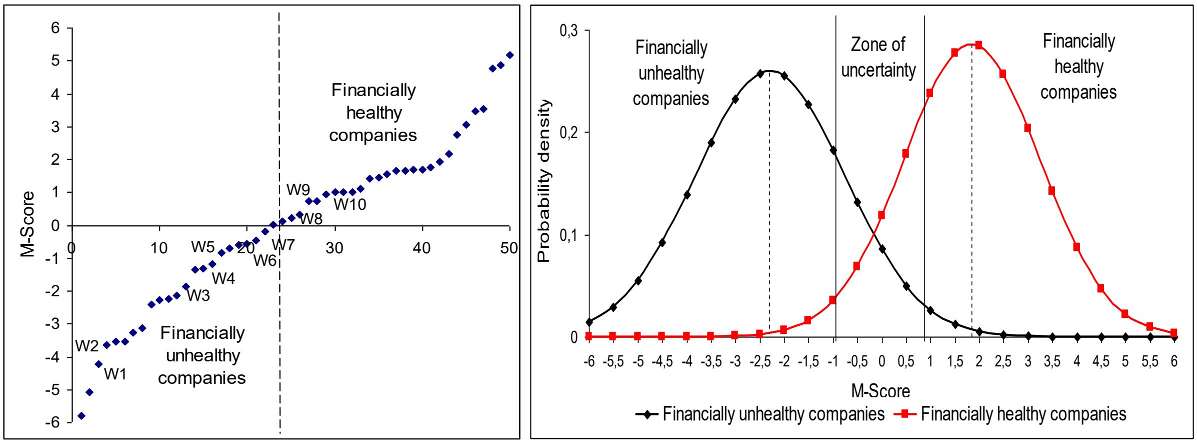
This function includes those ratios that signify the company's ability to pay back its liabilities with its assets (current ratio x_1) and the degree of financial independence of the company from external creditors (equity-assets ratio x_2). The function also includes capital productivity x_3, because due to significant depreciation of fixed assets of utilities, there is a problem with the duration and continuity of the provision of services, which negatively affects their financial health. As for the variable x_4 (gross profit ratio), taking into account the specifics of utilities (the definition of the tariff by the cost method, which involves summing up the cost price and profit), it is the level of the received profit that determines the possibility of financing the development costs, and consequently, the quality of services. The variable x_5 is the average accounts receivable turnover (days). This ratio is significant in assessing the financial health of municipal companies, since, for instance, in Ukraine, in addition to "usual" accounts receivable, there are often problems with the return of subsidies for services provided to socially unprotected layers of the population.

As for the assumptions of discriminant analysis, the following results are obtained. The initial groups of healthy and unhealthy companies we formed so that the assumption of equality of samples and the completeness of the data was fulfilled. With regard to the multivariate normality within groups, only current ratio x_1 and equity-assets ratio x_2 are distributed approximately normally. However, consistent with Tabachnick and Fidell (1989, p. 378), first, univariate F is robust to modest violations of normality as long as the violations are not due to outliers; secondly, MANOVA is also robust to modest violations of normality if the violations are created by skewness rather than by outliers. In order to find the outliers, we used the Hampel test. The capital productivity x_3 showed the largest number of emissions, but the reason for the abnormality is skewness. The excess kurtosis is equal to .86893. For a sample of size 25, the critical excess kurtosis value is .869 at 5% level of significance. Since the calculated value is less than the critical value, the Null Hypothesis of non-normality was rejected. The x_4 and x_5 series showed several outliers, and the excess kurtosis values are greater than the critical value. But we left all the variables, as the attempt to replace the company did not bring tangible results (we decided not to use other methods of eliminating outliers). Our strategy is consistent with Piotroski (2000, p. 16), who used “extreme portfolios to test the ability of fundamental analysis to differentiate between future winners and losers”. Multicollinearity within groups was evaluated by the Pearson correlation coefficient matrix. It was found that (i) equity-assets ratio x_2 and capital productivity x_3 show the highest degree of correlation in both groups (-.5971 and -.5716), and (ii) the determinants of the correlation matrices are .2853 and .3223. This degree of multicollinearity is acceptable in discriminant analysis.

After testing the assumptions, we estimated the parameters of the discriminant model and tested it. The estimation of the discriminant function (7), which is the foundation for our M-Score (Municipal-Score) model approach, is the function: $f(x) = .0505x_1 + 6.0638x_2 + .3870x_3 + .2193x_4 – .0004x_5$. The discriminant constant is equal to $c = 4.4234$, hence the estimated M-Score model is the following:

$$M\text{-}Score = .0505x_1 + 6.0638x_2 + .3870x_3 + .2193x_4 - .0004x_5 - 4.4234. \quad (8)$$

Thus, if the calculated M-Score is equal to 0 for a municipal company, then the probability that the company will be financially healthy is 50/50; if M-Score < 0, the probability of financial health is less than 50%; if M-Score > 0, the probability of financial health is greater than 50%, the larger the M-Score value, the greater the probability that the company will indeed be financially healthy. Figure 1 (a) illustrates the zones of discrimination as follows: M-Score > 0 – financially healthy companies (safe zone); M-Score < 0 – financially unhealthy companies (distress zone). To avoid confusion, Altman's definitions are given in parentheses (see, e.g., Altman & Hotchkiss, 2006, p. 246).



(a) (b)

Figure 1. Classification of municipal companies of the initial training sample: (a) the M-score values,* and (b) the probability density functions of normal distribution M-score

Note: * Wi (i=1, 2, ..., 10) – water utilities of the following Ukrainian cities: W1 – Chernivtsi; W2 – Kremenchuk; W3 – Cherkassy; W4 – Lviv; W5 – Kherson; W6 – Zhytomyr; W7 – Ternopil; W8 – Uzhgorod; W9 – Zaporizhzhya; W10 – Khmelnitsky.
Source: own calculations.

Obviously, the financial health of companies in the vicinity of zero is unsustainable or temporary, and therefore they can be mistakenly classified. Altman defined such a zone as the "zone of ignorance" or "gray zone" (Altman 1968; Altman & Hotchkiss, 2006). "Briefly, the "zone of ignorance" is that range of Z scores where misclassifications can be observed" (Altman 1968, p. 602). In addition, we will be uncertain about a new company whose M-Score value falls within the grey zone. Therefore, below we will establish rules for the classification of firms in this zone of uncertainty.

Before analyzing the results of discrimination of companies it is necessary to test the discriminatory power and classification accuracy of the M-Score model (8). The results of testing the discriminatory power of the model and financial ratios using the Wilks' Λ-test are presented in Table 3. Wilks' Λ shows how well a discriminant model separates companies into healthy and unhealthy. It can be seen from the table that the share of the total variance in the M-Score model, not explained by the differences between the groups, is 36.14%. The canonical correlation, as noted above, measures the relationship between M-Score and groups; the calculated value of .5152 indicates that the function discriminates fairly well.

For financial ratios, the values of Λ are much larger, but nevertheless, they are all statistically significant for discrimination between healthy and unhealthy companies. The greatest discriminant power is the equity-assets ratio, and the smallest is the gross profit ratio. The equity-assets ratio has the greatest impact which is also reflected in Table 3, where discriminant correlation shows the correlation of each financial ratio with the discriminant function. Thus, we may consider equity-assets ratio as the best separator. The average accounts receivable turnover is the next important separator, but in a negative sense, since the correlation is indirect (negative). This corresponds to the economic meaning of the M-Score: the greater the turnover of receivables, the lower the probability that the company will be financially healthy. There is practically no correlation between the gross profit ratio and the M-Score, but we do not remove this coefficient from the model since it is important for municipal enterprises.

Table 3. Results of testing the M-Score model

	Wilks' lambda	*F*	*P* value of the *F*	Discriminant correlation
M-Score	.3614	33.2220*	9.53E-08	1
Current ratio (x_1)	.9200	8.5263**	.0043	.4497
Equity-assets ratio (x_2)	.5913	67.7438	8.15E-13	.7418
Capital productivity (x_3)	.9338	6.9531	.0097	.3463
Gross profit ratio (x_4)	.9528	4.8577	.0299	.2904
Average accounts receivable turnover (x_5)	.9231	8.1667	.0052	-.4525

Source: own calculations.
Note: * the critical values of the *F*-distribution are as follows F (.05, 5, 94) = 2.3113,
** F (.05, 1, 98) = 3.9381.

However, the model did not perform perfectly because 5 unhealthy companies were classified as healthy, and 2 healthy companies were classified as unhealthy. This means that the Type I error is 20.0% and the Type II error is 8.0%; the model misclassified 7 out of 50 companies, or 14% of the sample, i.e., Hit Ratio is 86.0%.

The mean M-Score of the healthy companies is 1.852, while that for the unhealthy companies is -2.287. These means, along with approximations of the M-Score probability distributions of the two groups, are shown in Figure 1 (b). It is well known that if a random variable is normally distributed, then 95.44% of all its values fall within the two-sigma interval (this is a tighter than the bound of 75% that holds for an arbitrary distribution). In empirical researches, usually, the confidence interval of individual values is defined as the sample mean plus or minus two standard deviations ($m \pm 2\sigma$), which is very important in determining whether a company falls into a particular group. In our case, for unhealthy companies, the two-sigma interval is (-5.362, .789), and for healthy companies – (-.936, 4.639). The intersection of these intervals (-.936, .789) can be defined as a zone of uncertainty because we are not sure how to classify the company. Hence the corrected interpretation of the M-Score is as follows: if M-Score > .789, the company is financially healthy (safe zone); if M-Score < -.936, the company is financially unhealthy (distress zone); if -.936 < M-Score < .789, an unambiguous conclusion about the company's financial health cannot be made (grey zone). Nevertheless, it should always be remembered that (i) if the M-Score is negative, the probability of disaster is more than 50%, and (ii) the grey zone actually characterizes the critical health of the municipal company.

The results of classification accuracy using adjusted rule are displayed in Table 4.

The M-Scores for four unhealthy municipal companies are positive and have fallen into the grey zone: "Zaliznichneteploenergo" of the city of Lviv (.021), "Universal 2005" of the city of Kropyvnytskyi (.131), "Institute for Urban Development" of the city of Vinnitsa (.222), and "Vodokanal of the city of Uzhhorod" (.321). We removed these companies from the group misclassified companies. As a result, the classification accuracy of the model has changed: the Type I error proved to be only 4.0%, while Type II error is worse at 8.0%; the Hit Ratio is 94%.

Table 4. Accuracy matrix for initial training sample and test sample

Predicted membership / Actual membership	Unhealthy	Healthy	Total	Type error	Per cent correct	Per cent error
Initial training sample						
Financially unhealthy companies	24	1*	25	Type I	96.0	4.0
Financially healthy companies	2	23	25	Type II	92.0	8.0
Total	26	24	50		94.0	6.0
Test sample						
Financially unhealthy companies	31	5	36	Type I	86.1	13.9
Financially healthy companies	2	33	35	Type II	94.3	5.7
Total	33	38	71		90.1	9.9

Source: *own calculations*.
Note: * adjusted number of companies taking into account the zone of uncertainty.

The estimated discriminant model has good discriminant power, and although the above results are derived from an admittedly small sample of Ukrainian municipal companies, the potential implications are of interest. First, this model can be used to predict the company's financial health. Secondly, the M-Score can be used for a comparative analysis of the financial health of municipal companies, including by type of activity. The M-Score model is a combination of five financial ratios into a meaningful predictive model, therefore, is an understandable and comparable measure of the financial health of municipal companies. The value of the company's M-Score can help managers, creditors, investors, local authorities and the public to answer the following questions: Can the company avoid financial default? What is its position at the local level? What is its place in the industry? What is its place among similar companies in other municipalities?

4. Prediction results and discussion

In order to test the predictive performance of the M-Score model, we compiled a test sample using the 2016 and 2017 annual financial statements of 71 municipal companies. In addition to 50 Ukrainian companies, we will examine companies from 5 other countries in Central and Eastern Europe: Bulgaria (3), Croatia (3), the Czech Republic (7), Poland (2), and Romania (6). Table 4 shows the predictive accuracy of the model. The model mistakenly classified 7 out of 71 companies or 9.9% of the sample, i.e., Hit Ratio is 90.1%; the Type I error is 13.9%, and the Type II error is 5.7%. This is a high accuracy of the forecast, especially as shown in Table 5 the deviations from the gray zone are insignificant. In general, there are 16 companies in the gray zone or 22.5% of the sample.

In Table 5, companies are arranged in ascending order of M-Score; and we see that the companies are "grouped" not according to the countries (as might be expected), but by the nature of the activity and by the purposes of enterprise activity. In this study, we use the classifications of municipal enterprises proposed by American researchers (Government Information Division, 2004). Enterprises are allocated into categories based on the nature of the activity as follow: utility enterprises (water and sewer utilities, energy utilities, housing and utility enterprises), transportation enterprises, environmental enterprises, facility enterprises, community development, recreation enterprises, public safety enterprises, and miscellaneous. The second classification is based on three broad purposes of enterprise activity: necessary enterprises, quality of life enterprises, and enterprises for profit.

Expected results regarding the financial health of utilities are received. The initial sample of Ukrainian municipal companies includes 10 water utilities; 4 utilities are located in the zone of financially unhealthy companies, 5 utilities – in the zone of uncertainty and 1 utility – in the zone of financially healthy companies with M-Score equal to .944; for 7 utilities, the M-Score is negative (see Figure 1 (a)). Hence, an empirical conclusion is possible: the probability that the Ukrainian water utility will be really financially healthy is 10%; for 70.0% of Ukrainian water utilities the probability of disaster is more than 50%.

Table 5. The results of predictive discrimination

Municipal company	M-Score	Type of activity	Purpose of activity
“Water Supply and Sewerage Dobrich” (BG)*	-9.237	water	necessary
“Industrial” (Kyiv, UA)	-5.811	housing and utility	necessary
“Kharkiv thermal network” (UA)	-5.683	energy	necessary
“Center for Traffic Management” (Kyiv, UA)	-4.841	public safety	necessary
“Kremenchukvodokanal” (UA)	-4.051	water	necessary
“Zhytomyrvodokanal” (UA)	-3.920	water	necessary
“South-Western heat networks” (Khmelnytskyi, UA)	-3.692	energy	necessary
“Municipal enterprise Ltd. Knin” (HR)	-3.526	water	necessary
“Teploenergo” (Kremenchuk, UA)	-3.448	energy	necessary
SC Company water S.A. Buzău (RO)	-3.282	water	necessary
“Municipal enterprises Ltd. Križevci” (HR)	-3.238	water	necessary
“Chernivtsivodokanal” (UA)	-3.224	water	necessary
“Sofia Heating” Ltd. (BG)	-3.149	energy	necessary
“Lvivelektrotrans” (Lviv, UA)	-2.585	transport	life quality
“Lvivteploenergo” (Lviv, UA)	-2.550	energy	necessary
“Koprivnica water Ltd” (HR)	-2.401	water	necessary
“Cherkasyvodokanal” (UA)	-2.069	water	necessary
Water Supply and Sewerage Plovdiv (BG)	-1.816	water	necessary
“Kyivpastrans” (UA)	-1.750	transport	life quality
"Spetsservice-Kremenchuk" (UA)	-1.550	facility	necessary
“Zaliznichneteploenergo” (Lviv, UA)	-1.352	energy	necessary
Kyiv ME “Schoolchild” (UA)**	-1.187	miscellaneous	life quality
“Lvivvodokanal” (Lviv, UA)	-1.094	water	necessary
Municipal Water and Sewerage Company in Warsaw (PL)**	-.954	water	necessary
“Kyiv Hippodrome” (UA)	-.883	recreation	for profit
“Kherson Vodokanal” (UA)	-.876	water	necessary
“Ternopilvodokanal” (UA)	-.592	water	necessary
“School food” (Kyiv, UA)	-.475	miscellaneous	life quality
“Pharmacy” (Zhytomyr, UA)	-.460	facility	life quality
Municipal Water and Sewage Company in Cracow (PL)	-.375	water	necessary
“Exploitation of artificial constructions” (Zhytomyr, UA)	-.265	environmental	necessary
SC Termo Service SA (Iasi, RO)	-.260	housing and utility	life quality
Water Supply and Sewerage Breclav, Inc. (CZ)	-.198	water	necessary
Prague Water Supply and Sewerage, Inc. (CZ)	.044	water	necessary
“Universal 2005” (Kropyvnytskyi, UA)	.081	environmental	necessary
Funeral and cemetery services in Brno, Inc. (CZ)	.352	facility	necessary
“Vodokanal of the city of Uzhhorod” (UA)	.564	water	necessary
“Chernivtsispetskomuntrans” (UA)	.668	environmental	necessary
“Vodokanal” (Zaporizhzhya, UA)	.695	water	necessary
Water Supply and sewer Pardubice, Inc. (CZ)	.726	water	necessary
“Khmelnytskvodokanal” (UA)**	.825	water	necessary
Lviv ME «Administrative and technical organization” (UA)	.836	development	life quality
Brno Water Supply and Sewerage, Inc. (CZ)**	.977	water	necessary
Public transportation company Arad S.A. (RO)	1.050	transport	life quality
“Rembud” (Lviv, UA)	1.124	facility	life quality
Water Supply and Sewerage Prerov, Inc. (CZ)**	1.221	water	necessary
“Institute for Urban Development” (Vinnitsa, UA)**	1.353	development	life quality
“Kremenchuk trolleybus enterprise” (UA)	1.390	transport	life quality

“Ecology” (Kyiv, UA)**	1.397	environmental	necessary
“Zelenbud” (Chernihiv, UA)	1.411	environmental	necessary
“SC Public utility Cernavoda SRL” (RO)	1.532	energy	necessary
Iași Public Transport Company (RO)	1.533	transport	life quality
“Chernihiv trolleybus enterprise” (UA)	1.604	transport	life quality
“ATP-2528” (Chernihiv, UA)	1.631	environmental	necessary
Municipal House, Inc. (Prague, CZ)	1.644	recreation	life quality
“House” (Lviv, UA)	1.677	housing and utility	life quality
“Radiance” (Lviv, UA)	1.703	housing and utility	life quality
Khmelnytsky “Spetskomuntrans” (UA)	1.741	environmental	necessary
“Knyazhe misto” (Lviv, UA)	1.780	housing and utility	life quality
SC Public utility company Tirgu Ocna SA (RO)	1.876	facility	life quality
“Iceberg” (Lviv, UA)	1.904	housing and utility	life quality
Lviv Municipal Repair and Emergency Enterprise (UA)	1.954	facility	necessary
“Lvivsvitlo” (UA)	1.973	energy	necessary
“Green Lviv” (UA)	2.830	environmental	necessary
“Vinnytsya City Pharmacy” (UA)	2.879	facility	life quality
“Tourism Development Center” (Lviv, UA)	3.536	recreation	for profit
“Lutskreklama” (UA)	3.730	miscellaneous	for profit
“Stommaks” (Zhytomyr, UA)	4.008	facility	life quality
“Institute of Spatial Development” (Lviv, UA)	4.655	development	life quality
“Vinnytsyazelenbud” (UA)	4.786	environmental	necessary
“Market-household services” (Kropyvnytsky, UA)	12.695	facility	for profit

Source: *own compilation*.
Note: * the 2-letter codes are supplied by the International Organization for Standardization: BG – Bulgaria, CZ – Czech Republic, HR – Croatia, PL – Poland, RO – Romania, UA – Ukraine; ** companies were misclassified.

The same pattern is also observed in the test sample of municipal companies in CEE countries. The test sample includes 23 water utilities; 12 utilities are located in the zone of financially unhealthy companies, 8 – in the zone of uncertainty and 3 – in the zone of financially healthy companies with M-Scores equal to .825, .977 and 1.221; for 16 utilities, the M-Score is negative (see Table 5). Thus, the probability of financial health of the water utility in CEE countries is 13.0%, and for 69.6% of water utilities, the probability of disaster is more than 50%. This empirical conclusion agrees well with the conclusion on Ukrainian companies and indirectly confirms the discriminant and predictive performance of the M-Score model. As for energy utilities, 6 from 8 utilities of the sample are financially unhealthy. Unexpected for us was the conclusion that most of the environmental enterprises turned out to be financially healthy; 6 utilities are in the area of financially healthy, 3 – in the zone of uncertainty with the value of M-Score in the vicinity of zero. This is a good sign for cities.

With regard to the second classification of municipal companies, Table 5 shows that of the 45 necessary enterprises, 26 have a negative *M-Score*; only 12 enterprises are classified as financially healthy. However, these enterprises provide the life of the city, and therefore, irrespective of their profitability, they must function smoothly. The population buys services from the city, usually at a "social price"; these payments do not always cover the operating expenses of enterprises and do not create a reserve for the modernization of fixed assets. The system of state subsidies, as the research shows, does not always work well both in Ukraine and in other CEE countries. Probably, cities should investigate a possible increase in efficiency by contracting with private management companies; in this case, cities would retain control of the service, while benefiting from the expertise of an experienced provider (Government Information Division, 2004).

5. Conclusion

The study broadened the use of discriminant analysis in the assessment of the financial health of enterprises. We have focused on municipal companies in CEE countries because there are no such studies, while they are relevant in the context of decentralisation. To estimate the parameters of the discriminant model and verify its predictive performance, the data were collected from Bulgaria, Croatia, the Czech Republic, Poland, Romania and Ukraine. As a result, we obtained the M-Score five-factor discriminant model with high discriminant power and classification accuracy since (i) the share of the total variance in M-Score model, not explained by the differences between the groups, is 36.14%, and (ii) the Hit Ratio is 94%. The estimation of the discriminant model showed a number of significant and intuitively reasonable effects to aid the management of companies and local authorities. We found that the equity-assets ratio, the current ratio, and the average accounts receivable turnover have both the highest discriminatory power and the greatest impact on the financial health of municipal enterprises.

In addition, the proposed discriminant model overcomes the problem that we found in the literature related to the comparative analysis of the viability of municipal enterprises. Using the model, we empirically tested the hypothesis that the municipal company's financial health depends not on the region (city, community, country), but on the nature of the activity and the purposes of enterprise activity. Our substantive findings are that regardless of the region, water and energy utilities are generally financially unhealthy, and out of 45 so-called necessary enterprises only 12 companies are classified as financially healthy. However, these enterprises provide the life of the city, and therefore, irrespective of their profitability, they must function smoothly. At the same time, we received an unexpected result – most environmental enterprises are financially healthy. These conclusions have important implications for local authorities, particularly in light of decentralization trends.

In conclusion, it should be noted that, since not all issues of municipal companies and authorities are considered in this study, the priority directions for future research in this field are as follows: (i) evaluating the impact of utility activities on the viability of cities, and (ii) developing a model for assessing the financial health of municipalities in CEE countries.

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