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MODELS FOR CORPORATE FAILURE PREDICTION IN POLAND

This article presents the first models for business failure prediction, constructed with use of discriminant analysis and original Polish data. These models can be directly applied to explain and predict corporate failure in Poland and their forecast accuracy is comparable with the Altman's model.

INTRODUCTION

The purpose of this paper is to present the essential results of a study, undertaken in order to construct bankruptcy prediction models for Polish enterprises. As the phenomenon of bankruptcy has not had a long history in Poland, methods for its prediction have not been the subject of any research or practical application. For that reason it was not possible in the present analysis to refer to the Polish experience in this field. After consideration, the linear discriminant function has been chosen as the mathematical tool for model construction, since many empirical studies presented in the literature have proved that the accuracy of forecasts based upon this function were equal to, and in many cases better than, the accuracy of forecasts based upon other, more advanced and complicated methods (see Cochran 1964, Huberty et al. 1987, Press, Wilson 1978).

Failure prediction models constructed with the help of any quantitative method use, first of all, information provided by the financial ratios that describe the performance of companies. Prediction procedures are based on a general assumption that for any financial ratio included in the prediction model, its distribution in the population of bankrupt companies differs significantly from its distribution in the population of non-bankrupt companies. In the case of discriminant analysis, it is assumed that the considered financial ratios have a multidimensional normal distribution with an equal variance-covariance matrix in both populations and different vectors of the expected values in each of them. The expected values play an important role in the discriminant

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analysis because they describe the so-called economic and financial profile of companies from each considered population.

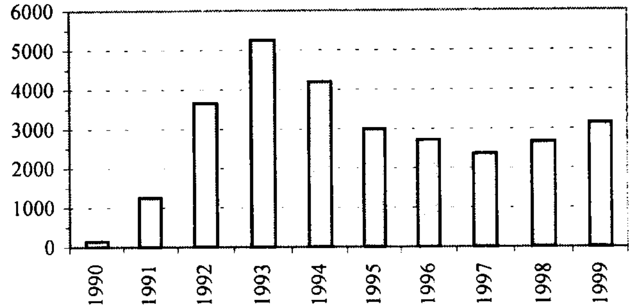
The analysis presented in the paper has been developed in three stages. After the preliminary list of the financial ratios had been established, it was verified whether the data available for model construction fulfilled the assumptions of the linear discriminant function, that is:

- whether the profile of bankrupt companies differs significantly from the profile of non bankrupt companies; and,
- whether financial ratios are normally distributed in both populations.

The purpose of the second stage of the analysis was to select from the preliminary list these financial ratios that significantly differentiate bankrupt and non-bankrupt companies in Poland. The ratios with the greatest discriminating power were then applied to model estimation. Finally, the quality of the constructed models was evaluated and the forecast accuracy of each model was considered and compared to the forecasts accuracy of Altman's model (see Altman 1983, p. 108), which is used in the present study as the reference model.

2. CORPORATE FAILURE IN POLAND – GENERAL CHARACTERISTICS

One of the most important negative phenomena resulting from the new economic system in Poland was the sudden increase of bankruptcy petitions in the early 1990s (see graph 1). It soon became apparent that the system of justice was not prepared for such a situation. Polish bankruptcy law, which originated in 1934, was not in use in the post-war period, and many of its solutions didn't fit the Polish economy in the transformation period. In practice, it was often overlooked that bankruptcy proceedings should first of all protect creditors and minimize the negative results of corporate insolvency on the economy. According to legal opinion, in the first years of the renewed operation of the law, dishonest entrepreneurs, in many cases, took advantage of the bankruptcy proceedings to achieve legally the liquidation of indebted enterprises and to start new activities. Since there was no obligation at that time to enclose financial reports with the bankruptcy petitions, the courts were able neither to reconstruct the corporate "way to failure" nor base their decisions on an analysis of the actual corporate financial situation.



Graph 1. Bankruptcy petitions submitted to the courts in Poland in 1990-1999
Source: Information Bulletins of the Ministry of Justice

The growing number of corporate bankruptcies in Poland has caused an increasing interest in this phenomenon and in the methods of its prediction. In several articles an attempt has been made to apply the Altman's famous model (see Altman 1983) to forecast the bankruptcy potential of Polish (publicly traded) companies (see for example Gasza 1997, Hoc 1994, Iwanicz 1995, Uberman 1994). Unfortunately, this approach is not appropriate, as there is no such general bankruptcy prediction model that would be universal and applicable for companies functioning in different economies. Altman suggested that accurate business failure forecasts can be obtained only under the conditions that the prediction models are developed utilizing "homogeneous groups of companies and data as near to the present as possible" (see Altman 1983, p. 125). For this reason there was an urgent need to construct prediction instruments adapted to Polish economic conditions, taking into account the specific features of this economy and including variables specific to this economy.

However, in order to create such instruments, it was necessary to obtain economic and financial data for failed companies. Unfortunately, no institution in Poland until recently collected and made available such information. Documents concerning failing companies have been collected only by the courts hearing the failure cases and, as already mentioned, for several years the failing companies were not obliged to submit financial reports to the courts. Therefore, many records concerning failure cases have not contained any financial information at all. The situation has now improved, thanks to the last amendment to the bankruptcy law on July 31st, 1997, but the database upon which the models for failure prediction can be built is still not large and of rather poor quality.

3. FINANCIAL RATIOS AS BUSINESS FAILURE PREDICTORS

From the variety of financial ratios available for the evaluation of the financial condition of companies, sixteen ratios were selected as potential indicators of corporate problems. The preliminary list of the financial ratios was established on the basis of:

- their popularity in the literature (ratios reliable for prediction of corporate failure);
- accessibility of suitable statistical data. Lack of source information for financial ratios used in the past studies prevents their use in the present analysis.

The ratios used for the model construction, which will be shortly presented, can be found in the literature (see for example Jachna, Sierpińska 1997). The ratios applied in the analysis were classified into four standard categories, describing a company's: liquidity, leverage, efficiency and profitability.

3.1. Liquidity ratios

$$W1 = \frac{\text{current assets}}{\text{current liabilities}}$$

The current ratio *W1* indicates the degree to which the current assets of an enterprise cover its current liabilities.

$$W2 = \frac{\text{current assets} - \text{inventory}}{\text{current liabilities}}$$

The quick ratio, *W2*, indicates the availability of current assets (less inventories) to meet current liabilities. Such a definition of the quick ratio permits the conversion of current assets into cash immediately – hence the name, "quick ratio".

$$W3 = \frac{\text{cash}}{\text{current liabilities}}$$

The cash ratio, *W3*, indicates the degree to which a company can immediately cover its current liabilities without selling components of its assets. The value of the ratio *W3* in a company is obviously lower than the value of the liquidity ratios *W1* and *W2*.

$$W4 = \frac{\text{working capital}}{\text{sales income}} = \frac{\text{current assets} - \text{current liabilities}}{\text{sales income}}$$

The ratio *W4* - the so-called intervals measure - characterizes the circulation of working capital in a company. Its value shows the number of days of turnover that can be covered with the working capital at the disposal of the company.

3.2. Financial leverage ratios

$$W5 = \frac{\text{total liabilities}}{\text{total assets}}$$

This so-called (total) debt ratio presents the share of borrowed capital in financing the total assets of the company.

$$W6 = \frac{\text{total debts}}{\text{equity}}$$

The debt-equity ratio is a relationship between borrowed capital invested in the company and its equity. The ratio *W6* shows the extent to which the company can cover all its debts with its own capital.

$$W7 = \frac{\text{working capital}}{\text{total debts}}$$

The ratio *W7* takes into account the liquidity of the company as well as its size. In past studies this ratio proved to be one of the most important predictors of corporate failure.

$$W8 = \frac{\text{fixed assets}}{\text{equity}}$$

The ratio *W8* indicates the extent to which fixed assets of a company are covered by its own capital.

3.3. Efficiency ratios

$$W9 = \frac{\text{receivables}}{\text{sales income}} \times 365$$

The ratio *W9* (average collection period) shows the circulation of the company's receivables (in days). This ratio characterizes the company policy towards its customers - its value presents the average period over which the company needs to collect its receivables.

$$W10 = \frac{\text{total liabilities}}{\text{cost of goods sold}} \times 365$$

The ratio *W10* characterizes the circulation of company liabilities (the ratio shows how many days the company needs to pay back its suppliers).

$$W11 = \frac{\text{sales income}}{\text{total assets}}$$

The ratio *W11* gives an insight into the assets turnover in the company and measures its ability to generate sales.

$$W12 = \frac{\text{inventory}}{\text{sales income}}$$

The ratio *W12*, the so-called inventory turnover, defines the number of days which the company needs to renew its inventories.

3.4. Profitability ratios

Especially important to the owners of each company is their return on equity, which shows how much profit is generated by one unit of invested capital. Unfortunately, this financial ratio had to be excluded from the empirical analysis, since its values ambiguously characterized the performance of enterprises. Profitability of equity was positive in two extreme situations: if the well functioning enterprise (with positive equity) created a net profit and if the enterprise being in bad condition (with negative equity) created a net loss.

$$W13 = \frac{\text{net profit}}{\text{total capital}}$$

Return on (total) assets defines the value of profit, generated by one unit of capital invested in the company.

$$W14 = \frac{\text{net profit}}{\text{sales income}}$$

This ratio (return on sales or profit margin) indicates how much profit is generated by one unit of sales.

$$W15 = \frac{\text{net profit}}{\text{fixed assets}}$$

This ratio (return on fixed assets) defines the value of profit per one unit of fixed assets engaged in the enterprise.

$$W16 = \frac{\text{net profit}}{\text{inventory}}$$

This ratio (return on inventories) defines the value of profit per unit of inventories maintained in the enterprise.

In the present analysis, the above-defined ratios have been accepted as potential predictors of corporate financial problems in Poland. Statistical procedures described in chapter 6 permitted selection from the preliminary list of these ratios that best differentiated the failed companies from the well-functioning ones.

4. SAMPLE SELECTION

Estimation of discriminant function parameters was carried out on the basis of data for bankrupt and non-bankrupt Polish companies. Two estimation samples were employed:

- basic sample, composed of 22 failed companies and 22 duly-paired non-bankrupt companies. For the companies in the basic sample relatively good financial data was available and therefore all 16 financial ratios mentioned above could have been considered.

- extended sample composed of 28 companies from each population. This sample contained six additional failed companies and six paired non-bankrupt companies. The financial data for failed companies, additionally considered in this sample, was rather poor. For that reason the model construction for the extended sample was based on only 11 financial ratios (see tables 1 (b) and 2(b)).

The failed enterprises included in both samples filed a bankruptcy petition in the years 1991-1997 and submitted it to one of the following provincial courts: in Poznań, Piła or Leszno. The selection of failed enterprises was not random, since we considered all those companies that had enclosed financial statements (balance sheet and income statement) with their bankruptcy petition. Companies included in the samples were stratified by size (measured by total assets), industry and ownership form.

An attempt was made to select carefully the non-bankrupt companies in both samples. Each failed company was paired with a solvent one of the same ownership form (a main criterion) and approximately the same size (in practice, the average size of a non-bankrupt company exceeded the average size of a bankrupt one). The non-bankrupt enterprises included in the analysis continued to function for at least one year after the reporting period when the financial statements (used for model estimation) were dated. Data for non-bankrupt enterprises originated from the same period of time (1991-1997) as the data for the failed ones. The source of these data was Monitor B.

Unfortunately, the available data were too limited to match the bankrupt and non-bankrupt companies in the samples by industry.

In order to verify the quality of the constructed models and to evaluate objectively the accuracy of the forecasts obtained on their basis, a so-called validation sample was created. The validation sample for non-bankrupt companies consisted of the same entities as the estimation sample, but the financial statements used for validation purposes were dated one reporting period later then the statements used for estimation purposes. Shortage of data restricted the validation sample for failed companies to only eight entities (different from those used for estimation purposes). For all companies included in the analysis, the financial reports were collected and data contained in these reports were used to characterize their financial performance.

5. ASSUMPTION VERIFICATION

As already stated, the construction of the linear discriminant function is based on an assumption that variables describing objects in the considered populations have multidimensional normal distributions with different vectors of expected values in each population and equal variance-covariance matrices. For the statistical significance of the obtained results, the observations from each population in the sample should satisfy this assumption. Therefore the subject of the statistical verification were:

a. whether expected values of the financial ratios for bankrupt companies were significantly different from their expected values for non-bankrupt companies;

b. whether the variance-covariance matrices for the financial ratios were in both populations equal (in practice we have only verified whether the variances of particular ratios were equal in both populations);

c. whether the ratios in both populations were normally distributed.

Tables 1(a) and 1(b) contain:

- mean values of the financial ratios for bankrupt and non-bankrupt companies in both samples. These mean values were sample estimate of the expected values of the ratios in the populations;

- coefficient R_k^*, which describes the relation between the mean values of each financial ratio for bankrupt and non-bankrupt companies.

The coefficient R_k^* is defined as follows:

$$R_k^* = \frac{\max\{\bar{x}_{0k}, \bar{x}_{1k}\}}{\min\{\bar{x}_{0k}, \bar{x}_{1k}\}},$$

where $\bar{x}_{ik}$ stands for the mean value of the variable (ratio) k in the sample drawn from the population i (i = 0, 1) (For the purpose of our analysis, it didn't matter which population is characterized by the higher expected value of the particular ratio). Of course, the closer the value of the coefficient R_k^* to one, the less different are the mean values of the ratio k in both populations. The negative value of this coefficient indicates that the mean values of the financial ratio in these populations are of different signs. In table 1(b) only these ratios are presented which could be calculated for all companies included in the extended sample.

Table 1(a)

Mean values of the financial ratios for bankrupt and non-bankrupt companies – basic sample

Financial ratio	Symbol	Mean value		R_k^*
		Bankrupt	Non-bankrupt	
Liquidity ratios				
- *current assets/ current liabilities*	*W1*	1.60	2.18	1.4
-*(current assets-inventory)/ current liabilities*	*W2*	1.05	1.28	1.3
- *cash/ current liabilities*	*W3*	0.12	0.35	2.8
- *working capital/ sales income*	*W4*	-3085.79	45.47	-67.9
Leverage ratios				
- *total assets/ total liabilities*	*W5*	1.19	0.44	2.7
- *total debts/ equity*	*W6*	-7.00	1.35	-5.2
- *working capital/ total debts*	*W7*	-0.34	0.16	-2.1
- *fixed assets/ equity*	*W8*	-4.18	1.01	-4.1
Efficiency (activity) ratios				
- *(receivables/ sales) x 365*	*W9*	444.12	43.97	10.1
- *(liabilities/ cost of goods sold) x 365*	*W10*	1600.71	86.57	18.5
- *sales income/ total assets*	*W11*	1.69	2.39	1.4
- *fixed assets/ equity*	*W12*	114.32	44.79	2.6
Profitability ratios				
- *net profit/ total capital*	*W13*	-0.37	0.03	-12.3
- *net profit/ sales income*	*W14*	-1.31	0.02	-65.5
- *net profit/ fixed assets*	*W15*	-2.64	0.16	-16.5
- *net profit/ inventory*	*W16*	-16.25	0.31	-52.4

Source: own calculations

Table 1(b).

Mean values of the financial ratios for bankrupt and non-bankrupt companies – enlarged sample

Financial ratio	Symbol	Expected value		R_k^*
		Bankrupt	Non-bankrupt	
Leverage ratios				
- total assets/ total liabilities	*W5*	1.15	0.48	2.4
- total debts/ equity	*W6*	-106.18	1.84	-57.1
- fixed assets/ equity	*W8*	-77.23	0.99	-78.0
Efficiency (activity) ratios				
- (receivables/ sales income) x 365	*W9*	371.41	51.48	7.2
- (liabilities/ cost of goods sold) x 365	*W10*	1342,12	108.50	12.4
- sales income/ total assets	*W11*	1.53	2.03	1.3
- fixed assets/ equity	*W12*	112.81	46.93	2.4
Profitability ratios				
- net profit/ total capital	*W13*	-0.39	0.04	-9.8
- net profit/ sales income	*W14*	-1.14	0.03	-38.0
- net profit/ fixed assets	*W15*	-2.26	4.39	-1.9
- net profit/ inventory	*W16*	-20.04	0.79	-25.4

Source: own calculations

Results from the above tables reveal that in only three cases in the basic sample, and in one case in the extended sample, does the coefficient R_k^* not differ significantly from one, which means that the expected values of the identified financial ratios in both populations are almost equal. In the remaining cases, the coefficient value indicates that the mean value in one population is a multiplication of the mean value in the second. Moreover, for all these ratios, which can take optionally positive as well as negative values, the coefficient R_k^* is negative, which results from the fact that the mean value of all these ratios for non-bankrupt companies is positive, whereas for failed companies - negative. The above situation occurred in the case of eight from the sixteen ratios considered.

Summarizing - the values of the coefficient R_k^* allow us to conclude that financial profiles of enterprises (described by the expected values of the analyzed ratios) are in the considered populations statistically different.

However, how informative the variable mean value is, depends on the variable variance (or standard deviation). If the standard deviation of a variable is very large compared to its mean value, then the mean value does not characterize the population properly. In our analysis the relation between mean value and standard deviation of each ratio in the population was characterized by the following coefficient:

$$R^*_{ik} = \left|\frac{\bar{x}_{ik}}{s_{ik}}\right| \text{ for } i = 0, 1$$

where $\bar{x}_{ik}$ - stands for mean value of the variable (ratio) k in the sample from population i;

s_{ik} - stands for the sample estimation of the standard deviation of the variable (ratio) k in the population i.

Table 2(a)

Relation between average values and standard deviations of the financial ratios for bankrupt and non-bankrupt companies - basic sample

Financial ratio – symbol	Value of coefficient R^*_k	
	Bankrupt	Non-bankrupt
W1	0.49	1.79
W2	0.49	1.47
W3	0.52	0.72
W4	0.27	0.85
W5	1.90	1.35
W6	0.38	0.43
W7	0.51	1.01
W8	0.27	0.81
W9	0.36	1.42
W10	0.30	1.43
W11	0.78	0.91
W12	0.49	1.03
W13	0.98	0.28
W14	0.42	0.35
W15	0.43	0.36
W16	0.46	0.38

Source: own calculations

Tables 2(a) and 2(b) contain the corresponding values of this coefficient for the basic and extended samples. These tables indicate that, for the majority of financial ratios used in the analysis, the standard deviation considerably exceeded the mean value and this relation was worse for the failed companies than the non-bankrupt ones. That leads us to the conclusion that, although the financial profiles of bankrupt and non-bankrupt companies in the samples were distinctly different, nevertheless their informative value was significantly decreased by the large dispersion (variance) of observations (numerous untypical observations, so-called outliers).

Table 2(b)

Relation between average values and standard deviations of the financial ratios for bankrupt and non-bankrupt companies - enlarged sample

Financial ratio – symbol	Value of coefficient R_k^*	
	Bankrupt	Non-bankrupt
W5	1.72	1.50
W6	0.20	0.52
W8	0.20	0.88
W9	0.34	1.46
W10	0.28	1.27
W11	0.72	0.98
W12	0.53	1.15
W13	0.99	0.33
W14	0.40	0.43
W15	0.41	0.19
W16	0.53	0.32

Source: own calculations

The above intuitive conclusions have been confirmed by the formal statistical tests. The results of the statistical verification for the basic and extended samples are contained in table 3. The symbol YES in this table means that a particular financial ratio has fulfilled the given assumption, NO - that the ratio has not fulfilled it. The number of YES and/or NO for each ratio in the table depends on the number of samples in which this ratio appeared. The sequence, in which these symbols appear corresponds to the basic sample (the first one) and to the extended sample (the second one, if two symbols appear). The verification has been carried out at the significance level $\alpha = 0{,}05$ using the following statistical tests:

- t statistic was calculated in order to compare the expected values in populations (the value of this statistic depends on the sample estimates of the mean values in both populations as well as on the assumption concerning un/identical variances in these populations)

- F statistic was calculated in order to compare the population variances (this statistic relates the estimates of variances for each ratio in both populations).

From table 3, we can infer that in most cases the analyzed ratios do not fulfil either the assumption that the expected values in both populations are different or the assumption that the variances are identical. The extension of the estimation sample (by including observations for an additional eight companies from each population) has not improved the verification results. As previously pointed out, the negative verification results were caused mainly by numerous untypical observations in the samples. Usually, in order to improve the informative property of the mean value, the procedure is to eliminate the outliers, which decreases the variable variance (and its standard deviation). Unfortunately, as with the present study, such a solution was not possible due to its relatively small sample size and lack of additional observations for failed companies.

Table 3

Statistical verification of the assumptions of linear discriminant function

Financial ratio	Different expected values in populations	Equal variances in populations	Normally distributed in populations
W1	NO	NO	NO
W2	NO	NO	NO
W3	YES	NO	NO
W4	NO	NO/ NO	NO
W5	YES/ YES	NO/ NO	NO/ NO
W6	NO / NO	NO/ NO	NO/ NO
W7	YES	NO	NO
W8	NO/ NO	NO/ NO	NO/ NO
W9	NO/ NO	NO/ NO	NO/ NO
W10	NO/ NO	NO/ NO	NO/ NO
W11	NO/ NO	YES/ YES	NO/ NO
W12	NO/ NO	NO/ NO	NO/ NO
W13	YES/ YES	NO/ NO	NO/ NO
W14	NO/ NO	NO/ NO	NO/ NO
W15	YES/ NO	NO/ NO	NO/ NO
W16	YES/ YES	NO/ NO	NO/ NO

Source: own calculations

In order to verify if the observations in each sample came from multidimensional normal distribution, the following statistical tests have been applied:

a. Shapiro-Wilks' test;

b. standardized skewness coefficient;

c. standardized kurtosis coefficient;

d. Kolmogorow-Smirnow test.

The verification procedure has brought us to the conclusion (see table 3) that no financial ratio in any of the considered populations is normally distributed. The final conclusion was the same for the basic as well as for the extended sample. The results of the presented analysis have confirmed the popular opinion that the normal distribution of economic variables (assumed in most of the empirical studies) is an exception than rather a rule.

Recapitulating the first stage of the analysis, it should be stated that the parameters of the discriminant function have been estimated although the data used for this purpose has not fulfilled any of the assumptions of the linear discriminant analysis. Therefore it could not be excluded that this fact would negatively influence the further results of the analysis, especially the quality of the obtained models and their prediction accuracy.

RESULTS OF MODEL ESTIMATION – CONCLUSIONS

In order to construct a "good" model for business failure prediction, the variables included in the model should:

- be weakly correlated with each other (so the variance-covariance matrix is well-conditioned);
- contribute significantly to the discriminating power of the function (so the model has a high prediction accuracy).

To select weakly correlated ratios for the model, the correlation matrices were used. Application of the trial-and-error method has allowed us to exclude three financial ratios: *W4, W6* and *W1O* from the list of the potential business failure predictors. The withdrawal of these ratios, highly correlated with the remaining ones, has resulted in obtaining models with better properties (higher discriminating power). In spite of the high correlation between the current ratio (*Wl*) and quick ratio (*W2*), they were not excluded from the preliminary list, since omitting any one of these ratios has decreased the quality (prediction accuracy) of the models later obtained.

The following variants of calculations have been carried out:

- forward and backward stepwise discriminant analysis;
- calculations for the basic and extended samples.

For the statistical verification of' the constructed models, tools for the analysis of variance have been applied. The discriminating power of the overall model with the selected variables was characterized by the so-called Wilks' *lambda* statistic. The value of this statistic is computed as the ratio of the determinant of the within-groups variance-covariance matrix over the determinant of the total variance-covariance matrix. Wilks' *lambda* can assume values from the interval 0 (for perfect discrimination) to 1 (for no discrimination). In addition the F approximation of this statistic was computed.

In order to evaluate the discriminant properties of each variable (financial ratio) currently in the model, the following statistics were used:

- Wilks' *lambda* for the overall model that would result after removing the respective variable from the model;

- tolerance value T_k defined by the formula $T_k = 1 - R_k^2$, where R_k^2 stands for the coefficient of multicorrelation between variable X_k and the remaining variables currently in the model. The tolerance is a measure of the redundancy of the respective variable. In the presented empirical analysis it was assumed that the tolerance value for any variable in the model should not exceed the level of 0.05 (in other words: each variable was 95% redundant with the other variables in the model).

For variables currently not included in the model so called partial *lambda* statistic λ_k^{cz} was computed, as the multiplicative increment in model *lambda* that would result from adding the respective variable X_k to the equation.

As a result of our calculations the following three models have been obtained:

MODEL 1:

$$D(W) = -2{,}50761 \times W5 + 0{,}00141147 \times W9 - 0{,}00925162 \times W16 + 2{,}60839$$

MODEL 2:

$$D(W) = 0{,}703585 \times W1 - 1{,}2966 \times W2 - 2{,}21845 \times W5 + 1{,}52891 \times W7 + 0{,}00254294 \times W9 - 0{,}0140733 \times W12 + 0{,}0186057 \times W16 + 2{,}76843$$

MODEL 3:

$$D(W) = -2{,}3001 \times W5 + 0{,}00153002 \times W9 - 0{,}0104159 \times W12 + 0{,}0286736 \times W16 + 2{,}65711$$

The models have been constructed in such a way that the positive *D(W)* value corresponds to the population of non-bankrupt enterprises, while the negative value corresponds to the population of failed enterprises. The applied estimation procedures ensured that the above models contain only statistically significant and lowly inter-correlated financial ratios.

From the information presented in table 4, note that four financial ratios: debt ratio (*W5*), average collection period (*W9*), inventory turnover (*W12*) and return on inventory (*W16*) appeared in all model equations; in addition: their coefficients had in all cases the same sign and almost the same value. This leads us to the conclusion that in Poland these financial ratios are the most important indicators of corporate problems which may result in the bankruptcy of the company.

Table 4

Financial ratios included in the prediction models

MODEL	Estimation variant	Financial ratios						
		W1	*W2*	*W5*	*W7*	*W9*	*W12*	*W16*
MODEL 1	Basic sample, forward discriminant analysis			●		●	●	●
MODEL 2	Basic sample, backward discriminant analysis	●	●	●	●	●	●	●
MODEL 3	Enlarged sample, forward & backward discriminant analysis*			●		●	●	●

* Both versions of calculations gave the same model equation.

Source: own calculations

The last task of our analysis was to decide which of the presented models is the best one and for that reason should be used for the prediction of business failure in Poland.

Table 5

Classification results

Firms	MODEL 1	MODEL 2	MODEL 3	Altman's model
ESTIMATION SAMPLE				
Non-bankrupt	90.91%	100%	89.29%	97%
Bankrupt	95.45%	90.91%	92.86%	94%
Total	93.18%	95.45%	91.07%	95%
VALIDATION SAMPLE				
Non-bankrupt	86.36%	81.82%	92.31%	79%
Bankrupt	100%	87.50%	100%	96%
Total	90%	83.33%	94.44%	83.5%

Sources: own calculations and Altman 1983, pp. 112, 115.

In order to solve this problem, the forecasts' accuracy was examined. Table 5 gives the information on classification accuracy in the estimation and validation samples for each of the considered models and for Altman's model. From the above table, it can be inferred that the classification accuracy for all three constructed models is very high. However, MODEL 1 and MODEL 3 proved to have higher accuracy (in the estimation as well as in the validation sample) with regard to the failed enterprises, while MODEL 2 in the estimation sample proved to have more accurate forecasts for non-bankrupt enterprises. As we are interested first of all in the accurate prediction of corporate failure, MODEL 2 is for us least useful. Although the two remaining models are practically equivalent – they contain the same variables and the accuracy of their forecasts is almost identical – there are two reasons to choose MODEL 1 as the better one:

- the basic estimation sample used for the construction of this model was smaller but more reliable than the enlarged sample used for the construction of MODEL 3 (financial statements for the failed enterprises constituting the basic sample were more complete and therefore all 16 ratios could have been considered);

- the corresponding value of Wilks' *lambda* statistic for this model amounts to $\lambda = 0.397$, whereas for MODEL 3 it amounts to $\lambda = 0.412$ (let us remember that the closer to zero the value of that statistic is, the higher the discriminating power of the model).

The comparison of the classification accuracy of MODEL 1 and Altman's model (see table 5) shows that their quality is comparable. It should be stressed that our model has better classification accuracy of bankrupt enterprises in the estimation sample than Altman's model.

The analysis presented in this paper gives fully satisfactory results as far as the statistical significance of the ratios included in the models and failure prediction accuracy are concerned. These useful results have been obtained in spite of the fact that both samples used for models construction did not meet the assumptions of linear discriminant analysis.

Although all the presented models can be used to predict financial distress of Polish companies in the transformation period with high accuracy, further research should aim at the construction of prediction models for more homogeneous groups of companies. Construction of these models should be based on actual, and possibly more reliable, data.

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