ZESZYT NAUKOWY
Wyższa Szkoła Zarządzania i Bankowości w Krakowie

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DISCRIMINANT MODELS IN PREDICTING BANKRUPTCY OF POLISH COMPANIES

Introduction

Discriminant analysis enables predictions of company bankruptcy. Selected models make it possible to assess company's financial condition and indicate bankruptcy risk. Indicators, which are based on the analyses of many companies, usually allow for distinguishing two categories: *bankrupts* and companies in a good economic situation, referred to as *healthy* ones.

It is accepted that bankruptcy prediction models are used in countries where they were developed. The reason for this, among other things, is that countries have their own accountancy regulations, and their financial statements differ, e.g. in form or structure. Consequently, the use of a foreign model may appear to be useless due to the existing differences. However, there are models considered to be global and universal.

The article presents four global models of bankruptcy prediction. They are E. Altman, G. Weinrich, G. L. V. Springate and O. Hajdu and M. Virag models. A thesis is presented that the universal structure of the above-mentioned models allows for their effective use in predicting the bankruptcy of Polish enterprises. The authors' research results are discussed along with the conclusions.

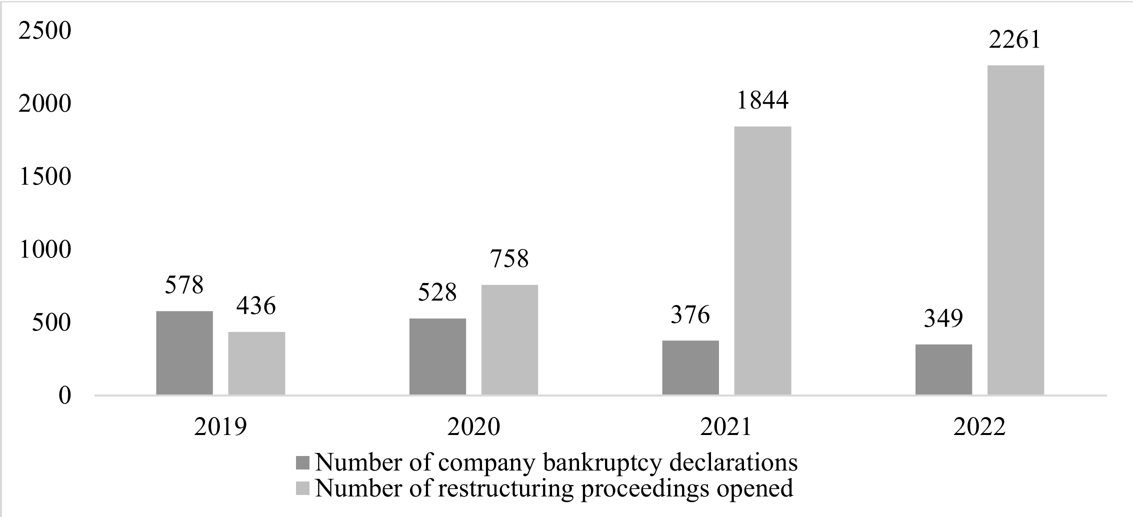
1. Bankruptcies of construction companies in Poland

According to the Bankruptcy Law, bankruptcy of an enterprise occurs when it is unable to repay its liabilities to creditors[1]. Company bankruptcy depends on the current market situation. During periods of economic downturn, the number of companies at risk of bankruptcy increases[2]. In recent years, this dependency could be noticed due to, among other factors, the

[1] Bankruptcy Law of 13 October 2003, cons. text, Journal of Laws of 2003, No.60, item 535, Art.10, as amended. 10.
[2] A. Kuciński, *Niewypłacalność, upadłość przedsiębiorstw,* Państwowa Wyższa Szkoła Zawodowa im. Jakuba z Paradyża w Gorzowie Wielkopolskim, „Studia i Prace Wydziału Ekonomicznego" 2013, No.5, p. 1.

consequences of the outbreak of the war in Ukraine or the Covid-19 pandemic[3]. Chart 1presents the number of bankruptcy decisions and the number of restructuring procedures opened.

Chart 1. Bankruptcies and restructuring of companies in Poland in 2019-2022



Source: Authors' research based on data provided by the Central Statistical Office (GUS) and MGBI Business Intelligence Agency, quote from: K. Stabryła-Tatko, *Skuteczność analizy dyskryminacyjnej jako narzędzia prognozowania upadłości przedsiębiorstwa*, unpublished diploma thesis, The School of Banking and Management in Krakow, 2023, p. 19.

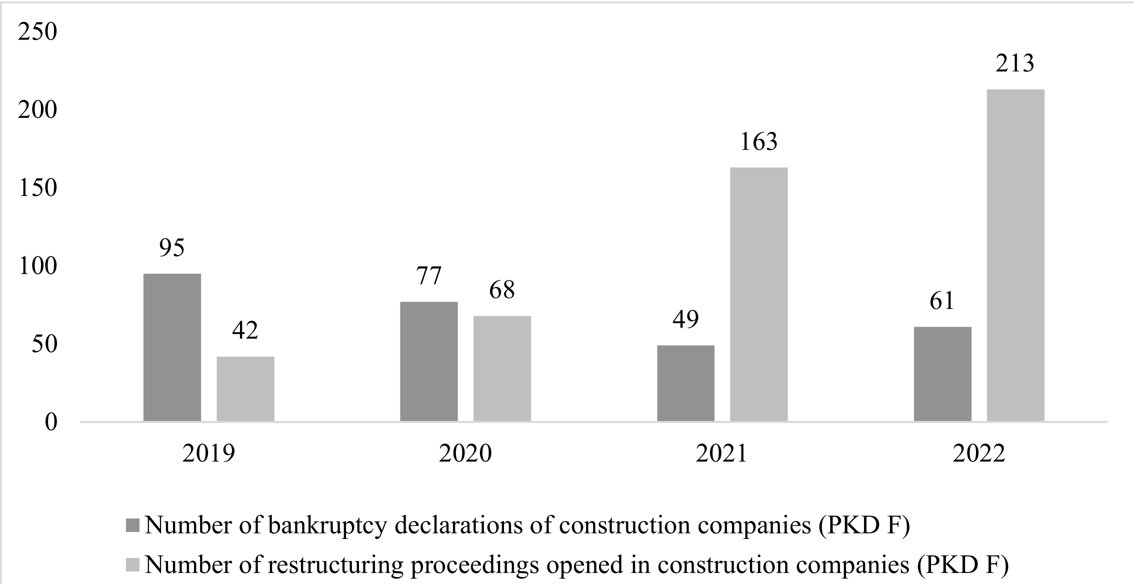
For several years in Poland, despite the cumulation of many crisis factors, the number of companies declaring bankruptcy has been decreasing and the number of restructuring proceedings has been increasing. This is the consequence of the change in regulations resulting from the introduction of the state of epidemical emergency in 2020. In order to meet the expectations of entrepreneurs, the government decided to introduce these provisions in the *Act on special solutions related to the prevention, counteracting and combating of Covid-19, other infectious diseases and crisis situations caused by them*[4]. The Act introduced several temporary changes in the provisions including the suspension of the obligation to file company bankruptcy petition within a specified period[5]. It was argued that the state of insolvency was caused by the outbreak of the COVID-19 pandemic and was only temporary. At the same time, the opening

[3] K. Stabryła-Tatko, *Skuteczność analizy dyskryminacyjnej jako narzędzia prognozowania upadłości przedsiębiorstwa*, unpublished diploma theses, The School of Banking and Management in Krakow, Krakow 2023, p. 4.
[4] *Act on special solutions related to the prevention, counteracting and combating of Covid-19, other infectious diseases and crisis situations caused by them*, consolidated text, Journal of Laws of 2020, item 374.
[5] Ibidem, Art. 19 para 1.

of restructuring proceedings gained popularity as it allowed companies to continue operating despite a real risk of bankruptcy.

The increasing significance of restructuring procedures could be noticed in recent years in, among others, construction companies. As a result, although the number of bankruptcies gradually decreased, the number of new restructuring proceedings dramatically rose. This is presented in Chart 2.

Chart 2. Bankruptcies and restructuring proceedings of construction companies (Polish Activity Classification F - PKD F) in Poland in 2019-2022



Source: Authors' research based on data provided by MGBI Business Intelligence Agency.

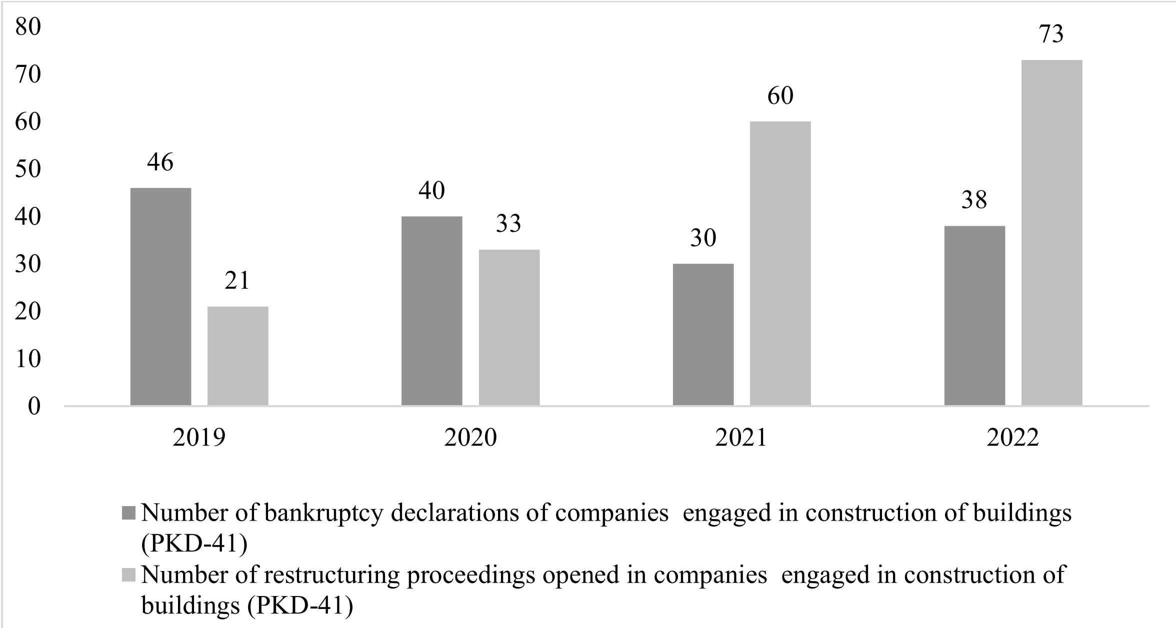
In 2020, an interesting phenomenon emerged. Contrary to the rest of the economy, there was a kind of "boom" on the property market which resulted in a dramatic growth. This was caused, among other reasons, by the fact that during the pandemic, consumers significantly verified their attitude to possessing a flat and the stagnation on the rental market led to a temporary decline in flat prices. Moreover, the progressive inflation and rising salaries motivated people to invest their savings. The combination of these factors resulted in a significant development of companies dealing with house building: the so-called developer's companies.

Unfortunately, the persistently high inflation and the rising purchase prices resulted in a significant decline in the number of flats sold in 2022[6]. This led to financial problems of many

6 https://serwisy.gazetaprawna.pl/nieruchomosci/artykuly/8648930,spadek-sprzedaz-mieszkan-2022-rok.html (Accessed: 20 September 2023).

companies whose funds were frozen in unsold investments. As a result, there was a growth in the number of companies engaged in construction of buildings. This is presented in Chart 3.

Chart 3. Bankruptcy and restructuring of companies engaged in construction of buildings (PKD-41) in Poland in 2019-2022



Source: Authors' research based on data provided by MGBI Business Intelligence Agency.

According to the data provided by MGBI Business Intelligence Agency in their report for 2023, the number of bankruptcy decisions in the whole construction sector, as in the case of the whole market, was gradually decreasing and there was a significant growth in the number of restructuring proceedings opened until 2021[7]. It should be noted that in 2022, while the number of bankruptcies of all companies decreased, the downward trend was reversed in the construction industry and, consequently, there was an increase in the number of bankruptcy declarations. Moreover, as in the case of the whole market, the upward trend continued in the number of restructuring proceedings opened.

[7] *Postępowania upadłościowe i restrukturyzacyjne. Raport 2023*, https://www.mgbi.pl/raporty/postepowania-upadlosciowe-i-restrukturyzacyjne-raport-2023/?utm_source=mailerlite&utm_medium=email&utm_campaign=Raport+Upad+o+ci+2023+-+launch+raportu#najwazniejsze-wnioski (Accessed: 15 September 2023).

2. Discriminant analysis

2.1. Structure of the models

Discriminant analysis is a statistical method used to divide information from financial statements according to s specific criterion and to organize it on the basis of many explanatory variables at the same time. Dependent variable is a quality variable[8]. To conduct company examination, a linear discriminant function, in the literature referred to as the Z-score function, is used. Discriminant function is the sum of the products of coefficients that characterize company's economic and financial situation and the weights that correspond to them, i.e. discriminant coefficients. The function form is given by formula 1.

Formula 1. Structure of a general discriminant function

$$Z_{score} = w_0 + w_1 \times x_1 + w_2 \times x_2 + \cdots + w_n \times x_n$$

where:

Z – discriminant function value, w_0 – constant value, w_i – (for $i = 1, 2, \ldots, n$) of the weight of selected variables, x_i - (for $i = 1, 2, \ldots, n$) model's explanatory variables .

Determining the value of the selected function by comparing it to a specific boundary value makes it possible to qualify appropriately the selected company. The most common division used by the authors of discriminant models is the division into two categories: *bankrupt*, i.e. a company that is at risk of bankruptcy and *healthy*, i.e. a company in which the value of the function exceeds a defined boundary value. This division allows for a clear assessment of the company financial situation[9].

3. Models of discriminant analysis

3.1. E. Altman's model

Edward Altman is considered a kind of a precursor of discriminant analysis models. His first model was developed in 1986 but the model presented below comes from 1983. This is due to the inadequacy of the first model to analyze companies that are not listed on the stock exchange. The structure of the model is given by formula 2.

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[8] A. Tłuczak, *Zastosowanie dyskryminacyjnych modeli przewidywania bankructwa do oceny ryzyka upadłości przedsiębiorstw,* „Zeszyty Naukowe Wyższej Szkoły Bankowej we Wrocławiu" 2013, No. 2(34), p. 424.
[9] Ibidem, p. 425.

Formula 2. E. Altman's model (1983)

$$Z = 0.717 \times x_1 + 0.847 \times x_2 + 3.3 \times x_3 + 0.42 \times x_4 + 0.999 \times x_5$$

where:

x_1 - $\frac{net\ working\ capital}{total\ assets}$, x_2 - $\frac{retained\ earnings}{total\ assets}$, x_3 - $\frac{EBIT}{total\ assets}$,
x_4 - $\frac{wequity\ market\ value}{book\ value\ of\ total\ liabilities}$, x_5 - $\frac{sales\ income}{total\ assets}$.

E. Altman distinguished three levels of the decision-making process that are dependent on the value of function Z[10]: $Z < 1.81$ – the company is at a serious risk of bankruptcy; $1.81 < Z < 2.99$ – the so-called "gray area", i.e. the risk is not defined; and $Z > 2.99$ – the company's position is safe and its financial situation is satisfactory.

3.2. G. Weinrich's model

In 1978, Gerd Weinrich examined 44 solvent and 44 insolvent companies. The companies were either small or medium-sized and run their operations in Germany. His model is given by formula 3.

Formula 3. G. Weinrich's model

$$Z = 0.1521653 \times x_1 + 0.9870483 \times x_2 - 0.0258087 \times x_3 + 0.0345653 \times x_4 - 0.0268425 \times x_5$$

where:

x_1 - $\frac{equity}{sales\ income}$, x_2 - $\frac{sales\ income}{total\ assets}$, x_3 - $\frac{sales\ income}{cash\ funds+receiva}$, x_4 - $\frac{stocks \times 365}{materials}$,
x_5 - $\frac{current\ liabilities-c\quad funds+receivable\quad short\ term\ securities}{net\ financial\ surplus}$.

The values of function Z were $Z > 47$ for solvent companies and $Z < -161$ for insolvent companies[11].

[10] T. Korol, B. Prusak, *Upadłość przedsiębiorstw a wykorzystanie sztucznej inteligencji*, Wydawnictwo CeDeWu, Warszawa 2022, p. 112.
[11] Ibidem, p. 143.

3.3. G. L. V. Springate's model

Another model that is based on discriminant analysis is the G. L. V. Springate's model, which was developed in Canada. Springate selected 4 out of 19 indicators that, in his opinion, best indicate a potential bankruptcy of a company. This model is presented by formula 4.

Wzór 4. G. L. V. Springate's model

$$Z = 1.03 \times x_1 + 3.07 \times x_2 + 0.66 \times x_3 + 0.40 \times x_4$$

where:

x_1 - $\frac{workig\ capital}{total\ assets}$, x_2 - $\frac{EBIT}{total\ assets}$, x_3 - $\frac{EBIT + interest\ paid}{current\ liabilities}$, x_4 - $\frac{sales\ revenues}{total\ assets}$

The boundary value for function Z that indicates potential company bankruptcy or its survival equals 0.862.

3.4. Virág -Hajdu model

The Hungarian model by Ottó Hajdu and Miklós Virág is a model with modified action. Contrary to the standard analysis methods with a defined boundary value that shows the risk (or the lack of risk) of bankruptcy, the model has two functions. They are the *bankrupt function* – $Z_{bankrrupt}$ which indicates the risk of bankruptcy, and the *healthy function* – $Z_{healthy}$ which shows the chance for company survival on the market. If $Z_{bankrupt} > Z_{healthy}$, company bankruptcy is not expected and its financial situation is assessed positively[12]. In the opinion of its authors, this model was adapted to the Hungarian economy. Its structure is given by formula 5.

Wzór 5. Virág -Hajdu model

$$Z_{bankrupt} = -7.73405 + 4.72122 \times x_1 - 0.22514 \times x_2 - 2.29162 \times x_3 + 0.21935 \times x_4$$
$$Z_{healt} \quad = -10.35017 + 3.07788 \times x_1 + 1.40883 \times x_2 + 1.37222 \times x_3 + 0.25301 \times x_4$$

where:

x_1 - $\frac{working\ assets - stocks}{current\ liabilities}$, x_2 - $\frac{cash\ flow}{total\ liabilities}$, x_3 - $\frac{cash\ flow}{total\ assets}$, x_4 - $\frac{working\ assets}{total\ assets}$

In later years, the Hungarian researchers developed a total of 26 models adapted to selected types of activities. None of the later developed models has ever been published and they are considered as trade secret[13].

[12] Ibidem, p. 134.
[13] O. Hajdu, M. Virág, *Hungarian model for predicting financial bankruptcy*, Budapest University of Economic Sciences, Budapest 2001, p. 14.

4. Methodology and the results of the authors' research

The research question of the authors of the paper was *whether it is possible to apply global models of discriminant analysis to predict the bankruptcy of Polish companies*. The research involved the use of four discriminant models coming from the US, Germany, Canada and Hungary. The authors used the models of E. Altman, G. Weinrich, G. L. V. Springate and O. Hajdu and M. Virag from 1983, 1978, 1978 and 1983, respectively.

The research was based on the data from financial statements provided by companies in a digital form in the Ministry of Justice database. It covered a period of one or three years before the bankruptcy was declared and involved four companies qualified as PKD 41 (division 41, section F), i.e. *construction of residential and non-residential buildings*[14]: Locum Developer, CH Estates, Diamond Properties and Ekoprojekt. All of them were limited liability companies and declared bankruptcy in 2021 or 2022.

The authors calculated the functions to determine if the companies should be qualified as *at risk* or *not at risk*. Two out of four models under analysis were in the so-called gray area, i.e. within a range of values that did not allow for a clear determination of the company's financial situation. The results of the research are presented in tables 1 – 4. The companies involved were assigned to letters of the alphabet as follows A – Lokum, B – C.H. Estate, C – Diamond Properties and D – Ekoprojekt.

Table 1. Discriminant analysis results for E. Altman's model

	3 years before bankruptcy declaration	2 years before bankruptcy declaration	1 year before bankruptcy declaration	Year of bankruptcy declaration
A	0.0592	5.841	-36.639	- 28.383
B	0.0559	0.101	0.220	- 0.152
C	- 0.622	- 95.407	- 38.429	- 193.183
D	- 2.149	- 1.605	-3.165	- 8.697

Source: Authors' research.

[14] *Sekcja F – BUDOWNICTWO*, https://klasyfikacje.gofin.pl/pkd/5,2,1467,roboty-budowlane-zwiazane-ze-wznoszeniem-budynkow.html (Accessed: 11 September 2023).

Table 2. Discriminant analysis results for G. Weinrich's model

	3 years before bankruptcy declaration	2 years before bankruptcy declaration	1 year before bankruptcy declaration	Year of bankruptcy declaration
A	16.361	49.083	9.683	44. 242
B	1.669	5.310	2.809	2.385
C	2.021	- 2.288	-	-
D	- 3470.469	-	- 3904.930	- 2863.897

Source: Authors' research.

Table 3. Discriminant analysis results for G. Springate's model

	3 years before bankruptcy declaration	2 years before bankruptcy declaration	1 year before bankruptcy declaration	Year of bankruptcy declaration
A	0.085	2.402	-67.574	- 0.746
B	0.434	3.151	1.104	-0.190
C	- 0.303	- 57.107	- 20.760	- 102.449
D	- 0.713	- 0.249	- 1.120	- 4.023

Source: Authors' research.

Table 4. Discriminant analysis results for O. Hajdu's and M. Virag's model

	3 years before bankruptcy declaration		2 years before bankruptcy declaration		1 year before bankruptcy declaration		Year of bankruptcy declaration	
	bankrupt	healthy	bankrupt	healthy	bankrupt	healthy	bankrupt	healthy
A	- 6.944	- 9.778	- 1.665	- 7.108	46.648	- 4.686	- 2.119	- 5.089
B	6.251	- 0.921	0.608	- 4.187	7.185	- 0.367	- 5.473	- 8.732
C	- 3.962	- 7.933	4.835	- 17.514	- 5.512	- 11.042	- 6.136	- 10.870
D	- 4.260	- 8.226	-4.351	- 7.846	- 4.568	- 8.697	- 5.039	- 10.281

Source: Authors' research.

5. Research conclusions

It can be concluded from the research that it is possible to use selected global discriminant models to predict bankruptcy of Polish companies. Moreover, in some cases they may be extremely effective. The Hungarian O. Hajdu and M. Virag model turned out to be particularly useful as in every company under investigation, irrespectively of the period preceding the bankruptcy, it indicated the dominance of the *bankrupt* function over the *healthy* function. This shows that this model predicts very effectively the possibility of declaring company bankruptcy.

The model developed in 1978 by G. L. V. Springate, a Canadian economist, and the E. Altman's model (the second one, developed in US in 1983)also proved to be very effective. Both models effectively predicted company bankruptcies in most cases.

G. Weinrich's model was the only one that did not perform well in predicting the bankruptcy of Polish companies. It predicted potential bankruptcy only in the case of one company but failed to show the risk of bankruptcy of the other companies under analysis. What is more, the model could not be used due to the impossibility to calculate selected indicators. This was caused by the lack of certain data in the financial statements of the companies under investigation. Such a situation leads to a conclusion that the lack of seemingly insignificant information from financial statements makes a model useless. The authors did not encounter this problem in the case of the other models under analysis.

Conclusions

The article presents the effectiveness analysis of four global discriminant models. The O. Hajdu and M. Virag model, which successfully predicted the risk of bankruptcy in all companies under investigation, was the most effective. The G.L.V. Springate's and E. Altman's models also showed high effectiveness, However, the G. Weinrich's model was ineffective. The authors proved the thesis that it is possible to use effectively foreign discriminant models in predicting the bankruptcy of Polish companies.

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[8] Act on special solutions related to the prevention, counteracting and combating of COBID-19, other infectious diseases and crisis situations caused by them, consolidated text, Journal of Laws of 2020, item 374.
[9] Bankruptcy Law, Act of 13 October 2003, consolidated text, Journal of Laws of 2003, No.60, item 535, Art.10, as amended.
[10] *Postępowania upadłościowe i restrukturyzacyjne. Raport 2023*. https://www.mgbi.pl/raporty/postepowania-upadlosciowe-i-restrukturyzacyjne-raport-2023/?utm_source=mailerlite&utm_medium=email&utm_term=2023-08-31&utm_campaign=Raport+Upad+o+ci+2023+-+launch+raportu#najwazniejsze-wnioski.
[11] *Sekcja F – BUDOWNICTWO*. https://klasyfikacje.gofin.pl/pkd/5.2.1467.roboty-budowlane-zwiazane-ze-wznoszeniem-budynkow.html.

Abstract

The article presents selected discriminant models. The study on their effectiveness was conducted during the period of four years before declaring the bankruptcy of construction companies (PKG-41). The analyses applied discriminant models from US, Germany, Hungary and Canada. The discussion of the results leads to the conclusion that the use of foreign models is possible in predicting the bankruptcies of Polish construction companies. However, a significant problem of the lack of data in the selected financial statements was noted, which made the use of particular models impossible.

Key words

Bankruptcy, discriminative analysis, bankruptcy prediction, construction industry.