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FAILURE AND INSOLVENCY. A PROPOSAL FOR POLISH PREDICTION MODELS[1]

BANKRUCTWO I UPADŁOŚĆ. POLSKIE MODELE PROGNOZY ZAGROŻENIA DALSZEGO KONTYNUOWANIA DZIAŁALNOŚCI PRZEDSIĘBIORSTWA

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Abstract: This paper discusses the problem of mutual use of the insolvency and bankruptcy variable for business failure modelling. The prior Polish literature on insolvency tends to focus on the qualitative research. This research shows how the terms *bankruptcy* and *insolvency modelling* on the informal dataset might result in different fits of the models. Models were estimated based on 17,024 firm's yearly observations from the 2004 to 2014 for the Polish financial market. Following prior research, the models were developed with application of the logit regression. The evidence gathered during the study supports the conclusion that the use of the legal definition of insolvency is a weak instrument for bankruptcy modelling.

Keywords: insolvency, bankruptcy, forecast, risk, continuation of activity.

Streszczenie: W artykule przedstawiono problem jednoczesnego użycia terminów "bankructwo" i "upadłość" w przypadku modelowania ryzyka kontynuowania działalności. Wcześniejsze badania ilościowe w dużej mierze jako zdarzenie powodujące przerwanie działalności przedsiębiorstwa rozpoznawały moment złożenia wniosku o upadłość. W dyskusji ekonomicznej formalno-prawne oznaczenie upadłości nie jest tożsame z bankructwem. Niniejsze badanie wskazuje na różnicę w dopasowaniu modeli w przypadku zamiennego potraktowania upadłości i bankructwa. Na podstawie 17 024 rocznych obserwacji z okresu 2004-2014 skonstruowano dwa modele predykcji dalszego kontynuowania działalności. Do estymacji parametrów modeli zastosowano regresję logistyczną. Uzyskane wyniki uzasadniają wniosek, że zastosowanie formalno-prawnej definicji upadłości nie jest dobrym instrumentem do modelowania bankructwa.

Słowa kluczowe: upadłość, bankructwo, prognoza, ryzyko, kontynuowanie działalności.

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1. Introduction

The problem to predict the situation weather the debtor will settle or not his liability is almost as old as the world. The goal of this paper is to construct both the insolvency and bankruptcy prediction models and to judge their equivalence.

This paper follows the seeming work of E. Altman [1968] on failure prediction. There is ongoing debate on the methods and ways of prediction of the failure of a business. The substantial part of this discussion is devoted to the search of the best modelling strategy in terms of the methods, independent variables and both time-span and geographical coverage. This paper offers a different perspective, namely it aims to explore the difference between different settings of the dependent variable.

Using the data set from the Polish business environment for the period 2004--2012 two models were constructed. Both models shared the same independent variables for the explanation of "insolvency" and "bankruptcy" term. The models were estimated with the application of the logit regression based on the sample of 17024 year-firm financial statements observations.

This paper contributes to the on-going debate on the robustness evidence that the "insolvency" is a weak instrument for "bankruptcy".

2. Literature review

The bankruptcy is a highly explored research area. Within the last two years (2015--2016) there were more than 30 papers indexed in the BazEkon repository. The detailed statement thereon is shown in Appendix 1. Just a simple overview of the goals of research indicates that the topic is not out fashion itself.

The discussion on bankruptcy can be broadly grouped into three areas. The fist focuses on the issue of the financial disability and its prediction [Altman 1968; Beaver 1966; Edmister 1972]. The second is dedicated towards the search for theoretical understanding of the insolvency process. The third explores the efficiency of proceedings [Camacho-Miñano et al. 2013; Luttikhuis 2009; de Weijs 2011].

This research is primary oriented on the first area. Already in prior research the authors put forward the issue of distinction between the "bankruptcy" and "insolvency" The first has economics roots. The second has the formal and legal background. The bankruptcy, loosely speaking, denotes the process of ceasing the entity from the business landscape, while insolvency is related to the launch of the formal legal procedure. R. Balina [2012, p. 159] defines a bankrupt company as the company that is not able to meet its financial obligation on time and the ongoing value of its assets is insufficient to cover the liabilities. B. Prusak [2002, p. 43] denotes a bankrupt company as one that is unable to sustain in the market without external help. A. Hołda [2007, p. 51] defines insolvency in three perspectives. First – economic: the impairment of the liquidity and assets value. Second – legal: court

resolution which constitutes insolvency. Third – psychological: a debtor's or creditor's awareness of a company meeting the legal conditions for an insolvency filling. D. Hadasik [1998, p. 17] by insolvency means a way for compulsory stopping of the business activity. T. Korol [2010, p. 24] associates insolvency with the act of filling the request for court protection or the court statement on enacting insolvency.

W. Rogowski [2015] indicated four criteria to distinguish "insolvency" form "bankruptcy", namely: character (legal or economic), option set agreement with the creditor (lack of this option in case of insolvency), legal definition (the law provides the definition only for "insolvency") and, last, the assets value condition as the entry requirement for insolvency proceedings. The Rogowski set can be enlarged with the time aspect. The insolvency moment is clearly stipulated with the low provision while "bankruptcy" tends to be rather a process. International studies apply the terms like "insolvency" [Rushinek, Rushinek 1987], "bankruptcy" [Altman et al. 2016], "failure" [O'Leary 1998], "non-going" [Yeh et al. 2014], "distressed" [Klepac, Hampel 2017] in different ways. For the purpose of this paper, we focus on the Polish local notation. Nevertheless, the literature stimulates the qualitative research of actual differences between "failure" and "insolvency" in terms of the risk quantification. Thus, the following set of hypotheses was developed for the study:

$H0_1$: *The same variables are significant both for insolvency and bankruptcy modelling.*
$H0_2$: *Prediction ability of both models is equal.*

In prior research on insolvency/failure/bankruptcy the research strategy focused on the identification of the sample of failed entities, which follows the selection of the healthy ones, either based on the statistical random or purpose sampling. Thereafter a potential set of independent variables were set in order to search for most efficient model [e.g.: Appenzeller, Szarzec 2004; Gajdka, Stos 1996; Hadasik 1998; Korol 2013; Korol, Korodi 2010; Korol, Prusak 2005; Mączyńska, Zawadzki 2000, 2001, 2006; Prusak 2005]. This paper offers a different strategy. The models take the set of independent variables based on prior research. Then both models for insolvency and bankruptcy are estimated and finally both are compared for similarities. This paper, however, focuses on the local market. Thus, it is somewhat limited by the linguistic issue, as the research is based on the semantic differences for the Polish market. A further study is needed to trace the international differences thereon.

3. Research design

Variable selection follows Camacho-Miñano et al. [2013] i.e. the Spanish market. It is the one that is the most like the Polish market in terms of the *ex-ante* efficiency. In this approach, insolvency is attributed to the filing of the protection

request at the court, while the bankruptcy is estimated as a mutual lack of the sufficient short and long-term financing for the company. If, at the balance sheet date, the current assets to total assets were less than two and total assets to total liabilities were less than one and a half, the entity was considered bankrupt. Both models share the same analytical form exempt from the dependent variable and is as follows:

$$Y^* = \beta_o + \beta_1 Size + \beta_2 \frac{KP}{TA} + \beta_3 \frac{NA}{KAP} + \beta_4 \frac{AK}{ZB} + \varepsilon,$$

$$Y = \begin{cases} 1 & Y^* \geq 0 \\ 0 & Y^* < 0, \end{cases}$$

where: Y^* is the latent variable, ε is the error term, while all the variables are defined in Table 1. Notably, Y is replaced with either the insolvency or bankruptcy indicator.

Table 1 presents definitions of the variables used in the study.

Table 1. Definition of variables

Name	Description
Size	Natural logarithm of total asset
KP/TA	Relation of working capital to total assets
NA/KAP	Debts to net equity
AK/ZB	Total assets to total liabilities
Dependent variables (Y)	
Insolvent	Variable value of 1 for entities which at the balance sheet date were at the insolvency proceeding, else 0.
Bankrupt	Variable value of 1 if meeting the Camacho-Miñano et al. Bankruptcy condition, else 0.

Source: own study.

Following prior research, the logit regression with the application of the maximum likelihood estimation and Quasi-Maximum Likelihood[2] standard error correction was selected for the model estimation. Two models separately were estimated for the dependent variable: Insolvent and Bankrupt. The binary panel data approach was rejected due to the data time series limitations. However, given the large size and diversity of the sample, there exists a risk of heteroskedasticity of the ε. In order to avoid potential inconsistency of the estimator, we apply Harvey's [1976] probit model with heteroscedasticity and allow the variance of ε to potentially be a function of additional regressors: the size of the companies and pre/during/post-crisis dummies.

The data was gathered from the insolvency courts in three major Polish cities: Wrocław, Warszawa and Gdańsk. The insolvency data was manually reconciled to

[2] Reassessment of standard errors based on negative hessian does not change the conclusions.

Table 2. Sample selection

Total observations available	17,494
Missing financial data	(470)
Usable sample	17,024
Number of companies	2,175

Source: own study.

the financial data bases: Amadeus, Oribs and Emis. The time span of observation is 2004-2012. The final usable sample consists of 17024 firms-yearly observations for 2175 entities. The data set was developed in the study by of Morawska and Staszkiewicz [2016a, 2016b]. Table 2 shows the sample selection.

4. Results and discussion

Table 3 presents the descriptive statistics of the sample.

Table 3. Descriptive statistics

Variable	Mean	Median	Min	Max	Stand. Dev.	Skw.	Kurtosis
Size	6.796	6.782	2.098	9.818	0.830	–0.076	0.635
KP/TA	–0.491	0.181	–1718	1.164	27.73	–57.609	3490.99
NA/KAP	7.253	1.480	–3215	11112	116.78	60.133	5216.23
AK/ZB	12.773	1.977	–3215	12633.4	217.74	39.703	1852.12
Bankruptcy	0.314	0.000	0.000	1.000	0.464	0.800	–1.360
Insolvency	0.126	0.000	0.000	1.000	0.332	2.248	3.055

Source: own study.

Table 3. Logit estimation model for insolvency and bankruptcy

	Insolvency	Bankruptcy
	$Y = 1$ for failure	$Y = 1$ for bankrupt
Const	–0.33	–5.7**
	(0.22)	(0.25)
Size	–0.28**	0.30**
	(0.028)	(0.027)
KP/TA	0.44**	–1.6**
	(0.095)	(0.087)
NA/KAP	0.44**	6.4**
	(0.095)	(0.17)
AK/ZB	7.2e–05	–0.056**
	(8.6e–05)	(0.015)
n	17024	17024
lnL	–6.4e+003	–4.5e+003

Note: In brackets estimation of errors; * significant at 10 percent; ** significant at 5 percent.

Source: own study.

The number of the bankruptcy cases is higher than the number of insolvency cases. Thus, the bankruptcy is a brighter concept. There is a class of the entities despite lack of short term and long-term liquidity that do not enter the insolvency path. Negative minimal values of the AK/ZB results from the disclosure of the overpayments of the liabilities. Table 3 presents the estimation model results.

Both models share the same variables; however, not all variables are significant, both for insolvency and bankruptcy, assuming typical level of significance. One of the ways to compare models' performance is based on the R-squared count. The in-sample model prediction success rates are shown in Table 4.

Table 4. In sample prediction success rate*

Panel A				Panel B			
	Insolvency model					Bankruptcy model	
		Predicted				Predicted	
		0	1			0	1
Actual	0	14,872	0	Actual	0	11,230	444
	1	2,152	1		1	1,051	4,299

* The bankruptcy model outperforms the insolvency model both in the information criteria and AUC.

Source: own study.

Based on the model, bankruptcy is more vivid than insolvency. While shifting from bankruptcy to insolvency, the model loses its fit and prediction ability. Additionally, the forecast errors in the case of the insolvency model are clearly asymmetric.

The models suffer, however, from close linearity for KP/TA and NA/KAP due to the outrage values in 1% of cases. Therefore, a straight application of the Spanish model into Polish framework is questionable. In addition, in large data sets the heteroscedasticity of ε in the latent variable equation might constitute an inconsistency issue.

Table 5. Alternative models' specification and AUC values

Variable excluded	Sample N	Logit		Probit		Probit_HF		Probit_HR	
		Ban	Ins	Ban	Ins	Ban	Ins	Ban	Ins
NA/KAP	17024	.989*	.582	.988*	.582	NA**	.580	.988	.580
	16485	.990	.620	.989	.620	.989	.623	.989	.621
KP/TA	17024	.991*	.582	.991*	.582	NA**	.580	.991*	.580
	16485	.992	.650	.991	.650	.992	.652	.991	.651

Note: Ban – denotes models with independent variable bankruptcy, Ins – denotes models with independent variable insolvency. Probit HF denotes the specification for probit heteresceadacitiy with two sets of potential control variables: size of entities and the timing of crisis. Probit HR denotes only control with size of variables as potential heteroscedasticity factors. *Convergence not achieved **NA – Not calculated due to the collinearity.

Source: own study.

We addressed the above concerns by additional robust and different specification testing. We applied 32 different models on the reduced model's specification with application of different estimation methods: logit, probit, probit with heteroscedasticity clustered on size of entities and on the pre-, during and post-crisis periods on the total and censored sample. Table 5 presents the summary of the AUC for the considered models.

The heteroscedasticity corrected reduced with KP/TA probit model with both size and crisis dummies as potential causes of heteroscedasticity are the most relevant for the comparison as we show in Table 6.

Table 6. Heteroskedastic probit model estimation for insolvency and bankruptcy on censored sample

Variable	Insolvency $Y = 1$ for failure				Bankruptcy $Y = 1$ for bankrupt			
	Parameter	Standard error	z	p(z)	Parameter	Standard error	z	p(z)
Regressors in the main equation								
Const	–0.63	(0.06)	–1.70	0.09	2.52	(0.57)	9.82	0.00
Size	–0.12	(0.19)	–6.41	0.00	0.42	(0.03)	12.80	0.00
KP/TA					–			
NA/KAP	0.52	(0.33)	15.43	0.00	4.30	(0.16)	27.16	0.00
AK/ZB	0.008	(0.001)	0.47	0.64	–5.27	(0.13)	–38.33	0.00
	Regressors of the error term variance							
Small	–0.10	(0.60)	–1.70	0.09	0.45	(0.10)	4.43	0.00
Big	–0.29	(0.82)	–3.60	0.00	–0.11	(0.14)	–0.08	0.94
Pre-crisis	0.14	(0.03)	0.53	–0.37	–0.22	(0.49)	–4.51	0.00
Crisis	0.05	(0.03)	1.96	0.05	0.42	(0.05)	0.86	0.39
N	16.485				16.485			
LR het*	22.66 (0.0001)				42.26 (0.0000)			
lnL	–5867.05				–1858.21			
AUC	0.652				0.992			

Note: *Heteroscedasticity LR test statistic (H0: constant variance).

Source: own study.

While in both models the variance of the error term is not constant (although the set of its statistically significant variables differs between the models), which suggests that the heteroscedastic probit models outperform the commonly used logit models with spherical errors, irrespectively of the estimation strategy the difference between bankruptcy and insolvency in fits is substantial. Not all variables significantly impact insolvency and bankruptcy.

The findings reinforce the theoretical discussion on the difference between insolvency and bankruptcy and indicates that insolvency is a weak instrument for bankruptcy.

5. Conclusion

The goal of this paper was a construction of two models. One for the insolvency and second for bankruptcy prediction. When constructing models on the same set of independent variables, the power of explanation of insolvency and bankruptcy is substantially different.

The results suggest that the interchange of insolvency and bankruptcy terms for modelling should be done with caution. The study has the commercial implication both for rating system and the failure predictions. It provides the arguments for the additional testing and robustness check of the existing models' settings.

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Appendix 1.

Area of bankruptcy research in 2015-2016 for semantic comparison*

Author/Year	Goal	Conclusion
1	2	3
[Szewc--Rogalska 2015]	Identification of risk sources of bankruptcy models of enterprises	Model risk results from 1) uncertainty as to the reliability of financial statements 2) model construction 3) model errors themselves
[Karaleu 2015]	Analyzing the tools available to defend workers' rights in the event of employer's bankruptcy (bankruptcy), e.g. using insurance instruments	All definitions refereeing to protection by the notion of insurance should be considered as inappropriate
[Karbownik 2015]	Identification of demographic characteristics of bankrupt entities from the TFL sector	A typical company threatened with bankruptcy is a micro-enterprise whose key activity is road transport of goods and service activities related to removals
[Gąska 2015]	The issue of bankruptcy forecasting with the application of the fuzzy classifier method was discussed (Maximum Margin Fuzzy Classifiers – MMCF).	Lack of unambiguous determination whether the MMFC method can be an effective means to predict bankruptcy for Polish enterprises
[Nowak 2015]	Showing the issues of enterprise survival in the area of management science	The institutional perspective enables an interdisciplinary approach to the study of the problem of enterprise survival. It integrates both internal and external factors
[Mączyńska 2015]	Indication for the opportunities for socio--economic development of Poland (New Secular stagnation Hypothesis).	Stagnation threats for Poland. Author points to the need to redefine socio-economic policy.
[Antonowicz 2015]	Application of the relative deviation of total costs to forecasting the bankruptcy of enterprises	The value of the deviation increases with the approach of the subject to bankruptcy
[Pisula et al., 2015]	Evaluation of non-statistical methods of bankruptcy prediction	Significant predictive power of non--statistical methods
[Bauer 2015]	Valuation of the historical value of real estate inhabited by the debtor and the risk of bankruptcy	Systematic understatement of property values in relation to fair value
[Maćkowska 2015]	Analysis of the development of the bankruptcy procedure	The development of legal norms allows a wider application of insolvency law institutions
[Dzyuma--Zaremba 2015]	Evaluation of the effectiveness of prediction models in case of sudden bankruptcy on the example Gant Development SA	Models maintain a high degree of discriminatory ability a year before filing for bankruptcy
[Sedláková 2015]	Presentation of bankruptcy prediction models	The prediction models are not immune to the business cycle.
[Bigaj 2015]	Describing the problem of recovering debts from the debtors with special regard to the period 2014-2016 in Poland	It can be expected that bankruptcies will be announced in Poland by citizens of other European Union countries

1	2	3
[Masiukiewicz 2015]	Changes in banking and the role of banks in the real economy give an argument to treat banks as a public good	Increased state participation in the banking sector
[Krajewska, Kudelska 2015]	Presentation of the specificity of the phenomenon of bankruptcy of enterprises in Poland in the years 2003-2013	There is a relationship between the number of bankruptcies and the dynamics of GDP
[Żabińska 2015]	Analysis of development trends in investment banking after Lehman Brothers bankruptcy	Deutsche Bank significantly reduced its activity in investment banking
[Lewandowska, Jakubczyk 2015]	Risk assessment of Alma Markets bankruptcy using prediction models	Based on prediction models, the risk of bankruptcy of Alma Markets SA was not identified
[Gąska 2016]	Forecasting bankruptcy of companies using classification methods, understood as a special case of learning under supervision, using financial indicators as characteristics	Empirical analyzes of failure forecasting fid not give a clear confirmation of the usefulness of Bayesian network learning methods in this area of issues.
[Jura 2016]	Presentation of the bankruptcy of public and non-public companies in Poland in 2004-2014	Public companies fall more often than on the non-public market
[Bauer 2016]	Analysis of the use of financial statements in bankruptcy proceedings	Relatively small use of financial statements in the practice of bankruptcy courts
[Fiedor, Hołda 2016]	The possibility of predicting bankruptcy based on price movement	As we move closer to the date of filing for bankruptcy, the predictive power of the price process increases
[Pikuleva 2016]	Analysis of the sovereign bankruptcy concept	Sovereign bankruptcy requires both establishment of a state bankruptcy institution at the theoretical level, as well as effective bankruptcy procedures
[Górsk et al. 2016]	Analysis of the predictive power of financial indicators used in the construction of functions in bankruptcy diagnosis models.	Differences in the construction of models are inconclusive
[Mihalovič 2016]	Construction of a bankruptcy prediction model for Slovak companies	The logit model has better properties than multidimensional discrimination
[Czernicki 2016]	Assessment of the introduction in 2014 of a new model of consumer bankruptcy in Polish law as an instrument to protect fair economic rights at risk of consumer bankruptcy.	The legislator has achieved the basic purpose of the regulation, which was to broaden the scope of protection of economic interests of Polish consumers
[Gurgul, Podczaszy 2016]	Differentiation of the bankruptcy and bankruptcy process	In economic practice, applications for bankruptcy are reported too late
[Kopczyński 2016]	Presentation of the results of two surveys on the identification of bankruptcy prediction methods used by Polish enterprises	Business entities operating in Poland do not use advanced tools to forecast bankruptcy

1	2	3
[Karbownik 2016]	To examine the statistical significance of the impact of selected macroeconomic variables on the level of financial risk of enterprises of the TFL sector in Poland	Macroeconomic variables should be included in the modelling of financial risk
[Boratyńska 2016]	Literature review combined with case analysis	Evolutionary economics It provides tools for describing bankruptcy processes
[Reizinger--Ducsai 2016]	Review of bankruptcy risk modelling in the light of Basel II implementation	Analysis of public data allows predictions of bankruptcy
[Paseková et al. 2016]	Assessment of the degree of satisfaction of the debtor after the amendment of the Act	Empirical studies indicate that the actual level of satisfying the creditor has been exceeded in relation to the minimum level required by law
[Sobociński et al. 2016]	Identification of development trends on the market	Probable crisis in the video game industry
[Sabuhoro 2016]	Comparison of the effectiveness of selected discriminant models and the bankruptcy probability measure in credit risk assessment	The degree of convergence of banking assessments in terms of credit risk with the indications of discriminant analysis models (88-94%) is higher than in the case of the modified bankruptcy risk measure

Note: *Papers with open access indexed in BazEcon.

Source: own study.