Warsaw School of Economics
Institute of Econometrics
Department of Applied Econometrics

Department of Applied Econometrics Working Papers
Warsaw School of Economics
Al. Niepodleglosci 164
02-554 Warszawa, Poland

Working Paper No. 4-05

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Paper presented to the 6th Conference "Financial Management – Business, Banking and Finance in Emerging Markets", Miedzyzdroje, Poland, May 2005.
Paper published in conference proceedings "Zarzadzanie finansami" ed. by D. Zarzecki, Szczecin, 2005.

This paper is available at the Warsaw School of Economics
Department of Applied Econometrics website at:
http://www.sgh.waw.pl/instytuty/zes/wp/

New bankruptcy prediction models for Polish companies

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Abstract

New logit models for predicting bankruptcy of Polish companies are presented. Major features of these approaches are: (1) selection of appropriate companies to the sample as the key step of the research, (2) well defined samples, (3) the reasoning based on the unified financial statements and (4) acceptable results of prediction – within samples as well as for the hold-out samples. In addition, the presented models of Stepien and Strak [2004], Ciesielski [2004] and Domeracki [2004] have been validated for the best companies on the Warsaw Stock Exchange. The validation principle states that the estimate of the probability of bankruptcy for such company shall be less than 0.5. New models for predicting bankruptcy of Polish companies well fit into the current research in the field of financial applications of microeconometrics.

Keywords: bankruptcy, financial distress, financial indicators, binomial logit

JEL codes: C25, G33

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1. Introduction

Main subject of the article is the presentation of a number of relatively new models of predicting bankruptcy for the companies in Poland. The research studies reported here are of microeconometric type and focus on the application of binomial logit. The typical data base for such research is composed of the court bankruptcy applications or resolutions, and of the companies' financial statements. The studies cover the period of 1996–2004.

The microeconometric approach to finance research studies for Polish companies could be implemented only recently, due to increasing accessibility of the companies' financial statements. The annual statements are published in "Monitor Polski B". Other sources include courts registers, stock exchange, securities' commission etc. There are also commercial data sources available.

The research on bankruptcy usually makes use of the bankruptcy applications or court resolutions. The resolutions are announced in "Monitor Sądowy i Gospodarczy", the applications need to be followed by researchers directly in the district courts.

There are various approaches to data collection for bankruptcy research. Some researchers prefer to classify bankrupt companies on the basis of submitted applications for bankruptcy (Hadasik [1998], Stępień, Strąk [2004], Domeracki [2004]). Other choose to count as bankrupt only the companies pronounced as such by the appropriate court (Ciesielski [2004]). There are also classifications based on the fact that the entities cease to submit their financial reports to Central Statistical Office (Hołda [2001]).

Nearly all bankruptcy models for Polish companies use the companies' financial ratios as the explanatory variables for their models. In this regard, Polish researchers follow the Altman type approach. The non-financial variables, such as industry-specific or ownership-structure variables are usually not present in Polish bankruptcy studies.

As to the methodology, the discrimination analysis is perhaps the most popular among finance researchers on Polish bankruptcy and financial distress. Other approaches include logit and probit models, of binomial and multinomial type, as well as neural networks.

2. Bankruptcy prediction vs. prediction of financial distress

Before proceeding further, it is worth to consider the distinction between bankruptcy prediction and the prediction of financial distress. The main methodological difference lies in the definition of the variable to be explained by the model.

In financial distress studies such variable y may be defined, for example, as:

$y_i = 1$ the i-th company is financially distressed ("severe problem" company),

$y_i = 0$ the i-th company is financially sound ("no problem" company).

In bankruptcy studies y typically denotes the binary fact of bankruptcy: either by the court resolution or by simple filing (application) for bankruptcy, e.g.:

$y_i = 1$ the i-th company is pronounced bankrupt (or the application for bankruptcy was submitted),

$y_i = 0$ the i-th company is not bankrupt.

Thus, the major question for the distress studies is how to "measure" the financial distress of a company, what is the cut-off point for distinguishing the financially sound company etc. Such studies were done in Poland e.g. by Batóg and Wawrzyniak [2004], by Gruszczynski and Wrona [2004] and by Gruszczynski [2004]. The first study classifies the companies as distressed and non–distress with the use of standard accounting bounds for selected four financial ratios. The latter two studies use for this purpose the indications of external models, ratings and expert opinions.

The distinction between financial distress models and bankruptcy models could be also found among explanatory (exogenous) variables–predictors. However, the common group of predictors in both types of studies includes financial ratios, calculated on the basis of recent companies' statements. The difference between distress and bankruptcy models can be stressed in the way of selection the non-financial variables. Yet, in the studies for Polish companies such variables are not frequently used.

As a result, for example, the typical specification of binomial logit model of distress/bankruptcy for Polish companies can be one of the following:

$$Probability\ (y_{it} = 1) = Logit\ (predictor\ variables_{t-1}) \quad (1)$$

$$Probability\ (y_{it} = 1) = Logit\ (predictor\ variables_{t-2}) \quad (2)$$

$$Probability\ (y_{it} = 1) = Logit\ (predictor\ variables_{t-3}) \quad (3)$$

where *Logit* denotes binomial logit, the term *predictor variables* indicates the list of predictors (financial ratios), year is denoted by *t*. The specifications assume that the probability of financial distress or bankruptcy of a company in year *t* may be determined by the values of its financial characteristics for the year *t*–1 or *t*–2 or *t*–3.

Even though the distress and bankruptcy models are similar in terms of explanatory variables, it is not advocated to compare their performance because the *y* variables explained in these two types of models might be substantially different[1].

In the next sections, the logit models obtained in three studies of bankruptcy in Poland are presented.

3. Models of Stępień and Strąk [2005] [2004a]

The research of Stępień and Strąk [2005], also reported in Stępień and Strąk [2004a] uses – among others – the logit specifications (1), (2) and (3). The research sample can be characterized as follows:

1. Number of companies: 1198.
2. Number of companies classified as bankrupt: 624
3. Time span: 1996-2001.
4. Sources of data for bankrupt companies:
   - applications for bankruptcy filed in the district courts of: Bydgoszcz, Gdańsk, Gorzów, Koszalin, Leszno, Piła, Poznań, Słupsk, Szczecin, Zielona Góra,
   - "Monitor Polski B",
   - Warsaw Stock Exchange.
5. Sources of data for nonbankrupt companies:
   - "Monitor Polski B",

[1] In the survey of Stępień and Strąk [2004] such oversight in comparison between models is present.

– Warsaw Stock Exchange.

6. Financial statements' lag: 1,2,3 or 4 years.

7. Sample structure:

A. Companies classified as bankrupt

B. Companies financially viable.

Sample	Specification	No. of companies A	B
basic	(1)	300	300
hold-out	(1)	167	214
basic	(2)	300	300
hold-out	(2)	142	213
basic	(3)	200	200
hold-out	(3)	101	299

Models reported by the researchers as the best specifications in (1), (2) and (3) include following predictors (financial indicators):

*X*1 – ROA,

*X*8 – profit (loss) on commercial activity/ total assets,

*X*34 – working capital/ total liabilities,

*X*72 – debt margin.

The estimation results are as follows:

Specification (1) – 1-year lag of predictors MODEL S1:

predictor	coefficient estimate
constant	5.83
*X*8	4.27
*X*34	2.00
*X*72	–7.78

Specification (2) – 2-year lag of predictors MODEL S2:

predictor	coefficient estimate
constant	3.97
*X*1	5.47
*X*34	1.66
*X*72	–5.78

Specification (3) – 3-year lag of predictors MODEL S3:

predictor	coefficient estimate
constant	2.43
*X*4	0.13
*X*72	–4.35

In the search for best predictors Stępień and Strąk used a number of postulates, along the proposals of Gruszczyński [2002]. The goodness of fit and the significance

tests for variables are not reported. Models S1, S2 and S3 have very good discrimination accuracy within and out of the sample. Total accuracy of classification is as follows:

	S1	S2	S3
Basic sample	91%	85%	80%
Hold-out sample	89%	84%	78%

4. Models of Ciesielski [2005]

Ciesielski [2005] uses specification (2), i.e. the models with two-year predictors lag. The sample may be characterized as follows:

1. Number of companies: 120.
2. Number of companies classified as bankrupt: 60
3. Time span: 2000-2002.
4. Sources of data for bankrupt companies:
   - bankruptcy resolutions by the court announced in "Monitor Sądowy i Gospodarczy" in 2002.
5. Sources of data for nonbankrupt companies:
   - "Monitor Polski B",
   - "Monitor Spółdzielczy B".
6. Financial statements' lag: 2 years.
7. Sample structure for specifications (2):
   A. Companies classified as bankrupt
   B. Companies financially viable.

Sample	Specification	No. of companies	A	B
basic	(2)		40	40
hold-out	(2)		20	20

The group of bankrupt companies selected primarily to the sample included 96 companies, for which the financial statements from 2000 were available in "Monitor Polski B" and "Monitor Spółdzielczy B". This group has been tailored in order to reflect the structure of the economy in 2002. As a result, 40 bankrupt companies were selected to the basic sample: 12 companies representing manufacturing, 16 companies representing commerce, 5 construction companies, 4 service companies (real estate, manage-

ment, science) and 3 other companies (food processing, transportation, financial services).

The following predictors are included in Ciesielski's specifications:

PMO – reserves and short-term liabilities/ current assets,

NKA – surplus (deficit) in working capital/ total assets,

(working capital demand is defined as working capital minus net cash),

KA – working capital/ total assets,

BP – current ratio,

RZ – liabilities turnover (net sales/ short term liabilities)

OZ – debt margin,

PO – gross profit (loss) plus interest/ interest,

WO – net cash flow from operating activities/ total assets,

ROA,

KWA – shareholders' equity plus long-term liabilities/ total assets.

Ciesielski proposes 3 specifications of type (2). Logit models' estimates are as follows:

Specification (2) – 2-year lag of predictors MODEL C1:

predictor	coefficient estimate	
constant	–3.18543	
PMO	0.51114	
NKA	–1.15192	
BP	–0.32734	
RZ	–0,11627	
OZ	5.57730	*
PO	–0.03178	*
WO	–5.26458	*
McFadden's R2	0.55160	

Specification (2) – 2-year lag of predictors MODEL C2:

predictor	coefficient estimate	
constant	0.79459	
PMO	0.25829	
NKA	–4.48416	*
KA	0.47588	
RZ	–0.19866	*
PO	–0.00866	*
ROA	–7.59912	*
WO	–2.14254	
McFadden's R2	0.51330	

Specification (2) – 2-year lag of predictors MODEL C3:

predictor	coefficient estimate	
constant	2.71010	
PMO	–0.04507	
BP	–0.02004	
KWA	–7.13808	*
RZ	–0.09405	
PO	–0.02330	*
ROA	–9.24862	*
WO	–5.07261	*
McFadden's R2	0.59230	

Asterisk denotes the statistical significance of a variable. Models C1, C2 and C3 have 7 predictors, which number should be considered rather large. The algorithm of choosing the best predictors is similar to that used by Stępień and Strąk for the models reported in the preceding section. The goodness of fit of Ciesielski's models is represented by McFadden's R-square.

Models C1, C2 and C3 have following accuracy within and out of the sample:

	C1	C2	C3
Basic sample	86%	86%	88%
Hold-out sample	75%	80%	83%

5. Models of Domeracki [2004]

Research of Domeracki [2004] is based on specification (1), i.e. the models with one-year predictors lag. The sample is as follows:

1. Number of companies: 122.
2. Number of companies classified as bankrupt: 61
3. Time span: 2000-2002.
4. Sources of data for bankrupt companies:
   - bankruptcy applications filed in the Warsaw district court in 2002-2004.
5. Sources of data for nonbankrupt companies:
   - rankings of "Gazele Biznesu 2002" and "Gazele Biznesu 2003",
   - "Monitor Polski B".
6. Financial statements' lag: 1 year.
7. Sample structure for specifications (1):

   A. Companies classified as bankrupt

B. Companies financially viable.

Sample	Specification	No. of companies	A	B
basic	(1)		50	50
hold-out	(1)		11	11

Companies financially viable were chosen from the ranking of the best small and medium enterprises "Gazele Biznesu". The predictors included in Domeracki's specifications are as follows:

*X*3 – acid test ratio,

*X*5 – debt margin,

*X*6 – liabilities and reserves/ shareholders' equity,

*X*11 – net sales/ total assets,

*X*13 – inventory turnover,

*X*14 – ROA.

There are 3 specifications of type (1) by Domeracki. Logit models' estimates are as follows:

Specification (1) – 1-year lag of predictors MODEL D1:

predictor	coefficient estimate	
constant	8.89527	
*X*3	12.18447	
*X*5	–8.74973	*
*X*6	0.09944	
*X*11	2.43543	*
*X*13	0.00169	
*X*14	20.77614	*
McFadden's R2	0.55160	

Specification (1) – 1-year lag of predictors MODEL D2:

predictor	coefficient estimate	
constant	8.92057	
*X*3	12.1139	
*X*5	–18.6390	*
*X*6	0.09928	
*X*11	2.40859	*
*X*14	20.8771	*

Specification (1) – 1-year lag of predictors MODEL D3:

predictor	coefficient estimate	
constant	5.64289	
*X*3	26.2483	
*X*5	-8.50311	*
*X*6	0.056583	
*X*14	11.26546	*

Asterisk denotes the statistical significance of a variable. The choice of predictors in models D1, D2 and D3 was based on the procedure similar to that used by authors of models presented in previous section.

Models D1, D2 and D3 have following accuracy within and out of the sample:

	D1	D2	D3
Basic sample	96%	96%	90%
Hold-out sample	91%	91%	95%

6. Out of sample validation

Models presented in sections 3–5 have been validated for the companies listed on Warsaw Stock Exchange. Companies selected for the validation test are the best in their industrial sectors – as shown in a separate research by Gruszczynski and Wrona [2004]. These companies had the smallest estimates of the probability of financial distress, calculated on the basis of 2003' financial results. 13 companies have been selected from 13 sectors, excluding banks and insurance sector.

The validation test states that the estimate of the probability of bankruptcy for such company shall be less than 0.5. Another words, it is not likely that the company with good financial standing (in 2003) has significant prospects of going bankrupt, say, in one or two years.

Therefore, bankruptcy prediction models presented in previous sections have been applied to the financial data on 13 selected companies. Table 1 presents the results.

There are 3 estimated bankruptcy probabilities for each company reported in Table 1 (all figures as percentages). Model S denotes the average estimate of using S1 and S2 models, i.e. this is the estimate of bankruptcy probability in 1-2 years. Model C presents average from models C1, C2 and C3: probability of bankruptcy in 2 years. Model D (average from D1, D2 and D3) shows bankruptcy probability in 1 year.

Table 1 shows relevant probabilities for each year from the period 2000-2003. Sample periods for the original models suggest that S and C may best represent years 2000-2002, while D may be better associated with 2001-2003.

Table 1. Estimates of bankruptcy probability for selected companies listed on Warsaw Stock Exchange in 2000-2003 (in percentages)

Company	Model	2000	2001	2002	2003
Food sector:	S	5.4	2.3	5.2	4.9
Żywiec	C	27.9	17.1	19.3	14.0
	D	1.3	0.0	0.0	0.0
Light industry:	S	7.3	24.0	43.1	38.9
Novita	C	8.0	37.3	50.6	44.4
	D	0.0	0.5	47.8	32.3
Wood processing:	S	33.3	40.2	24.0	2.5
Paged	C	51.5	63.3	53.0	22.4
	D	2.1	2.1	8.7	0.0
Chemical sector:	S	14.2	10.9	6.7	9.2
Polfa Kutno	C	17.3	18.0	13.8	15.8
	D	2.1	0.4	0.1	0.1
Construction	S	0.9	0.9	1.0	1.1
materials:	C	4.4	2.6	7.9	6.6
Lentex	D	0.0	0.0	0.0	0.0
Construction sector:	S	3.4	4.9	7.8	3.9
Prochem	C	26.6	16.4	33.2	18.4
	D	0.0	0.0	0.0	0.0
Electrical	S	4.5	9.9	15.5	8.1
machinery:	C	12.8	19.8	31.8	13.0
Remak	D	0.3	2.0	1.4	0.0
Metal industry:	S	1.5	1.3	1.9	1.9
Mennica	C	3.5	5.8	15.2	3.3
	D	0.0	0.0	0.0	0.0
Commerce:	S	31.8	34.8	40.8	40.0
Prosper	C	51.1	53.2	57.1	46.8
	D	0.3	5.4	13.8	12.5
IT:	S	12.0	26.4	16.9	1.6
Sterprojekt	C	34.4	43.7	38.0	10.6
	D	1.0	7.4	2.5	0.0
Telecom sector:	S	25.0	32.7	31.1	30.6
TPSA	C	23.7	34.0	35.5	37.6
	D	2.4	12.8	13.9	7.0
Media:	S	1.3	0.8	2.8	3.0
Agora	C	3.4	2.2	8.0	5.8
	D	0.0	0.0	0.0	0.0
Other services:	S	2.0	2.3	2.2	7.1
Orbis	C	6.1	9.7	7.4	32.5
	D	0.0	0.0	0.0	0.1
Averages	**S**	**11.0**	**14.7**	**15.3**	**11.8**
	C	**20.8**	**24.8**	**28.5**	**20.8**
	D	**0.7**	**2.3**	**6.8**	**4,0**

Source: own calculations

In all instances the predicted probabilities of bankruptcy for the year 2003 are smaller than 50%. It means that models pass such validity test. It is interesting that all averages are lower for 2003 than for 2002. This is in accord with macroeconomic performance of Polish economy.

The estimates of bankruptcy probability for models C are about 2 times higher than for models S. The estimates resulted from models D are much lower than those for models S and C. This may mean that models D underestimate the bankruptcy probability for the listed companies. Another explanation is the sample structure for models D: bankrupt companies are there confronted with the companies being business leaders. Such sample may perform well for classifying companies but it is not precise in predicting probabilities.

7. Conclusion

The new logit models for predicting bankruptcy of Polish companies presented in the paper have a number of common features which are worth to point out in the conclusion:

- all models are specified after very careful selection of the sample of bankrupt and non-bankrupt companies;
- samples are well defined; this first step of the research seems to be decisive for the research outcome;
- all predictors used in the reported research are financial ratios calculated from the companies' financial statements;
- in each case the choice of predictors to the final model is based on the algorithm utilizing both statistical properties of the sample and the characteristics of resulting estimated equation;
- number of predictors used in the models is small, with the exception of models by Ciesielski; more predictors in the model do not guarantee better prediction performance;
- prediction accuracy of the models is high, both within samples and for the hold-out samples;
- all models pass the simple validation test for the out-of-sample companies on the Warsaw Stock Exchange.

In our opinion, the new models for predicting bankruptcy of Polish companies well fit into the current research in the field of financial applications of microeconometrics.

Further research in this area shall focus on refining the samples of companies and on introducing non-financial predictors to the models.

References

1. Batóg B., Wawrzyniak K. [2004], Diagnozowanie i prognozowanie kondycji spółek giełdowych za pomocą modeli probitowych i logitowych, *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, No 389, Szczecin, 2004.
2. Ciesielski P. [2004, 2005], Prognozowanie prawdopodobieństwa upadłości podmiotów gospodarczych w Polsce na podstawie modeli mikroekonometrycznych, M.A. thesis, Warsaw School of Economics, 2004; *Rachunkowość*, 2005.
3. Domeracki M. [2004], Zastosowanie analizy dyskryminacyjnej oraz modelu logitowego/ probitowego do prognozowania upadłości przedsiębiorstw w Polsce, M.A. thesis, Warsaw School of Economics, 2004.
4. Gruszczyński M. [2002], *Modele i prognozy zmiennych jakościowych w finansach i bankowości*, Oficyna Wydawnicza SGH, Warszawa, 2002.
5. Gruszczyński M. [2004], Financial Distress of Companies in Poland, *International Advances in Economic Research*, November 2004, Vol. 10, No. 4, s. 249-256.
6. Gruszczyński M., Wrona K. [2004], Spółki giełdowe i pozagiełdowe w Polsce: relacje fundamentalne, *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, No. 389, Szczecin, 2004.
7. Hadasik D. [1998], Upadłość przedsiębiorstw w Polsce i metody jej prognozowania, *Zeszyty Naukowe. Prace Habilitacyjne*, No. 153, Economic Academy, Poznań, 1998.
8. Hołda A. [2001], Prognozowanie bankructwa jednostki w warunkach gospodarki polskiej z wykorzystaniem funkcji dyskryminacyjnej ZH, *Rachunkowość* 5/2001.
9. Stępień P., Strąk T. [2004], Weryfikacja skuteczności wybranych modeli oceny zagrożenia bankructwem, *Zarządzanie Finansami. Finansowanie Przedsiębiorstw w Unii Europejskiej*, Szczecin, 2004.
10. Stępień P., Strąk T. [2004a], Dwumianowe modele logitowe oceny zagrożenia bankructwem przedsiębiorstwa, *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, No. 389, Szczecin, 2004.
11. Stępień P., Strąk T. [2005], Dwumianowe modele logitowe oceny zagrożenia bankructwem przedsiębiorstwa, *Folia Oeconomica Stetinensia*, 2005.