NBP Narodowy Bank Polski

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Approach to the assessment of credit risk for non-financial corporations. Poland Evidence

Contents of the presentation

I

Introduction and literature review

Motivation for the Assessment of Credit Risk

- Assessment of Credit Risk, and especially ensuring accuracy and reliability of credit ratings by means of validation is of critical importance to many different market participants (Winkler, 2005).

- Key Purposes for the Assessment of Credit Risk of Companies by Central Banks (Winkler, 2005):
  - Keeping track of the (*credit risk of the*) economy from a macro-economic perspective
  - Assessing credit quality of collateral in the context of monetary policy operations
  - Assessing and ensuring financial market stability from a macro- prudential perspective

Aim

- This paper presents the **1 year Probability of Default (PD) Model** and **Rating System** for non-financial corporations in Poland.
  - The purpose of the **Scorecard** is to differentiate between good and bad firms by estimating the **Probability of Default (PD)** during the following 12 months.
  - The aim of a **Rating System** is to classify companies according to the probability of *default* over a given period.

Main steps in developing a rating system

Literature review - Credit Scoring Statistical Techniques

Method	Authors
Weight-Of-Evidence measure	*Bailey, 2001; Banasik et al., 2003; Siddiqi, 2006; Abdou, 2009*
Regression analysis	*Lucas, 1992; Henley, 1995; Hand and Henley, 1997; Hand, Jacka, 1998*
Discriminant analysis	*Altman, 1968; Desai et al., 1996; Hand and Henley, 1997; Caouette et al., 1998; Hand et al., 1998; Sarlija et al., 2004; Abdou and Pointon, 2009; Wiginton, 1980; Crone, Finlay, 2012*
Probit analysis	*Finney, 1952; Grablowsky and Talley, 1981*
Logistic regression	*Lenard et al., 1995; Desai et al., 1996; Lee and Jung, 2000; Baesens et al., 2003; Crook et al., 2007; Abdou et al., 2008; Wiginton, 1980; Yap, Ong, Husain, 2011; Kočenda, Vojtek, 2009;* Stepanova, Thomas, 2002; Thanh Dinh oraz Kleimer, 2007; *Crone, Finlay, 2012*
Linear programming	*Yang, Wang, Bai, Zhang, 2004*
Cox's proportional hazard model	Stepanova, Thomas, 2002
Support Vector Machines	*Deschaine and Francone, 2008*
Decision trees	*Baesens et al., 2003; Stefanowski and Wilk, 2001; Thomas, 2000; Fritz and Hosemann, 2000; Hand and Jacka 1998; Henley and Hand, 1996; Coffman, 1986; Paleologo et al., 2010; Yap, Ong, Husain, 2011; Kočenda, Vojtek, 2009; Frydman, Altman, Kao,1985; Novak, LaDue, 1999; Thomas, Bijak, 2012; Crone, Finlay, 2012*
Neural Networks	*Amari, 2002; Al Amari, 2002; Gately, 1996; Irwin et al., 1995; Masters, 1995; Palisade Corporation, 2005; Desai, Conwey, Crook oraz Overstreet,1996; Crone, Finlay, 2012*
Genetic algorithms and genetic programming	*Goldberg, 1989; Koza, 1992; McKee and Lensberg, 2002; Etemadi et al., 2009; Huang et al., 2006; Huang et al., 2007*
Markov switching model and Bayesian estimation	*Chuang & Kuan, 2011; Frydman & Schuermann, 2008; Jacobs & Kiefer, 2011; Tasche, 2013*

Literature review - Calibration and mapping to Ratings

- To transform a credit ***score*** into a ***probability of default* (*PD*)**
  - **The first** one includes methods approximate the conditional (*on default and non-default*) score distributions into parametric distributions
    - Dey, 2010; Bennett, 2003; Krężołek, 2007; Tasche 2006; Tasche 2008; Tasche 2009
  - **The second** one includes methods for dummy variable (*default or non-default*) models
    - Tasche, 2009; Neagu, Keenan, 2009; Koenker, Yoon, 2009 ; Neagu, Keenan, Chalermkraivuth, 2009; Zadrozny, Elkan, 2002; Van der Burgt, 2008
- After obtaining ***PD*** values, *scores* were mapped to ratings according to the *master scale*.

II

Data description

Data sources

Companies	Financial institutions	Court
Financial statement data	**Prudential Reporting**	**Judicial events**
• *AMADEUS (Bureau van Dijk)* • *Notoria OnLine*	• *NB300 (Narodowy Bank Polski)*	• *The National Court Register*
2007 – 2012		

- The following sectors were removed from the Polish Classification of Activities 2007 sample: section A (*Agriculture, forestry and fishing*), K (*Financial and insurance activities*).
- The following legal forms were analyzed:
  - Partnerships (*unlimited partnerships, professional partnerships, limited partnerships, joint stock-limited partnerships*);
  - capital companies (*limited liability companies, joint stock companies*);
  - civil law partnership;
  - state owned enterprises;
  - branches of foreign entrepreneurs.

Data sources

- The sample included companies observed in 2011.
  - In Model the *default probability* was predicted for a one year horizon.

- For the definition of the total number of obligors the following selection criteria were used:
  - The company is existent (*operating and not liquidated/in liquidation*) throughout the entire respective year
  - The company is not in *defaul*t (*neither insolvency criterion nor other types of default according to the CRR definiton*) at the beginning of the year
  - The total exposure reported at least 1.5 Mio EUR for each reporting date.

- Impaired Loans:
  - loans from portfolio B for which objective evidence of impairment and decrease in the value of expected cash flows have been recognised (*in banks applying IFRS*) or loans classified as irregular pursuant to the Regulation of the Minister of Finance regarding principles for creating provisions for the risk of banking activity (*in banks applying the Polish accounting standards*).

III

Review of Rating System

Sample design

- Models were estimated on databases which included ***all companies that went defaults as well as randomly chosen healthy companies***.
  - Then the dataset was randomly split into **development** and **validation sample** containing 70% and 30% of the data, respectively.
- Prior to the estimation the model, it was tested in order to ascertain whether the constructed sample was representative.

- Analysis of the company's financial position around **4 axes**:
  - Profitability, financial autonomy, financial structure, liquidity
    - The analysis included not only the current values of the indicators but also their statistical properties (*for example the median*) based on different time frames (*for example a 2-year average*).

Methodology - PD model

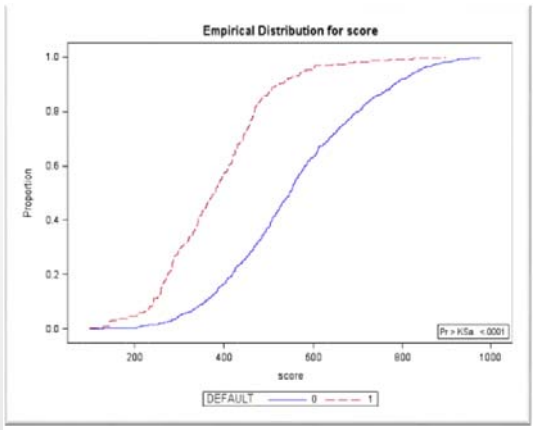
- The analysis was performed with the use of a logistic regression on categorized variables transformed using the weight of evidence approach (*WOE*).
  - The categorisation was based on the division with the highest information value (*IV*), which measures the statistical Kullback-Leibler distance (*H*) between the defaults and non-defaults.
  - Scoring methods have been used to create an indicator for grading the companies in the case of *defaults*.
- Due to **a high number of financial indicators** describing a company's condition (explanatory variables) in the initial analysis, the predicting power of each was determined firstly (*Gini coefficient*, *Information Value Indicator*) followed by clustering in order to limit the size of the analysis.
- Thanks to this variable selection procedure it was possible to avoid the collinearity problem, which was assured by calculating the appropriate *Variance Inflation Factor* statistics.

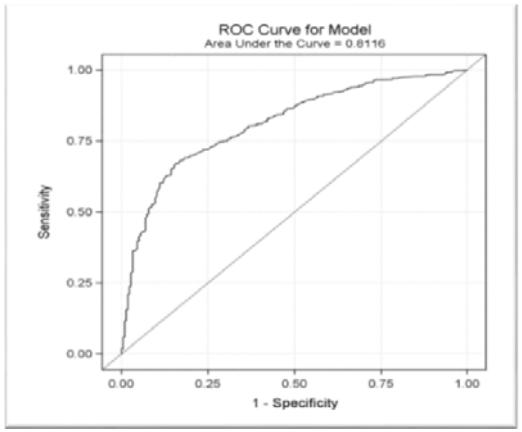
Results - Final scorecard

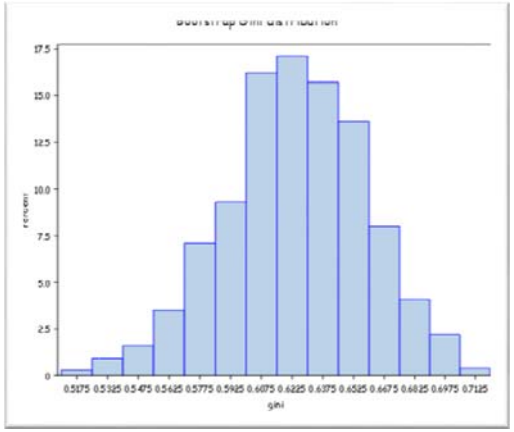
Variables	Weight in the total grade in %	Value		Partial grade
Credit period (days) (Creditors / Operating revenue) * 360	6,16%	-INF	36.175	57
		36.175	73.873	34
		73.873	+INF	0
Industry sectors	8,84%	Industry		83
		Construction		0
		Trade		108
		Transport		31
		Other services		43
EBIT	8,04%	-INF	372	0
		372	4696	44
		4696	+INF	78
Bank-firm relationships	11,80%	one bank		99
		two or more banks		0
ROCE	6,87%	-INF	-4.501	0
		-4.501	12.641	59
		12.641	+INF	85
ROA	**16,39%**	-INF	-10.49	0
		-10.49	1.907	53
		1.907	6.502	91
		6.502	+INF	189
Solvency ratio (Liability based)	7,96%	-INF	26.221	0
		26.221	54.097	30
		54.097	94.483	50
		94.483	+INF	80
(Interest due / Total exposure)*100 (*median of 4 q*)	14,05%	-INF	0.016	121
		0.016	0.035	89
		0.035	0.193	44
		0.193	+INF	0
(Bank loans denominated in PLN / Total exposure)*100 (*median of 6 q*)	9,33%	-INF	6.796	84
		6.796	67.72	44
		67.72	+INF	0
(Open credit lines / Total exposure)*100 (*median of 6 q*)	10,53%	-INF	1.553	0
		1.553	23.77	25
		23.77	+INF	99
Hosmer - Lemeshow Test		Test statistic 11,1666		**p-value** 0,1924

Results – Validation *PD Model*

Empirical distribution for score (*K-S*) on development sample	ROC curve	Results of bootstrap analysis for *Gini* coefficient







Value of score at Maximum = 483

- **Gini** coefficient and **KS** for the modeling sample for the above model is equal to **62,3** and **51,4**.
  - To test for *Gini* coefficient stability the bootstrap analysis was performed. For 1000 iteration the following results were achieved. Gini coefficient is equal to 62.
- **Population Stability Index** was used to test for variables' time stability. As suggested by literature the rule of rejecting the hypotheses that default rate distributions are close to each other is when PSI exceeds 0.25. *Default rate* distributions for the model observation date (*2011*) were compared to 3 other moments in time.
- The model was then re-estimated on *holdout* and *out of time sample* to check for the significance of variables.

Methodology - Calibration & Mapping to rating

- In order to perform the calibration, the scores were bucketed with (more or less) same number of defaults in each bucket. After that, **Default Rate** in each bucket was transformed.
- Such modified Default Rate was transformed into **odds**.
- The theoretical relationship between the **score** and **logarithm of odds** (*which from the nature of logistic regression should be linear*) was used to obtain estimates of the **calibration function**.

- The accuracy of obtained estimated PD's for each calibration function was tested - **Population Stability Index**.
  - According to common usage of the *PSI*, values between *0* and *0,1* mean no significant changes.
  - Population Stability Index between observed and predicted *PD* is equal *0,003* and shows that there are no significant changes.

Results - Rating

in 2012

Number of obligors	Thereof insolvent	Thereof defaulted	Insolvency rate	Default rate
5091	28	298	0,55%	5,85%

Rating

Rating	Min score	Max score	Masterscale average PD	Estimated PD	Observed PD
1	977		0,07%	0%	0%
2	897	977	0,14%	0,15%	0,98%
3	811	896	0,28%	0,31%	0,42%
4	725	810	0,57%	0,59%	0,50%
5	638	724	1,13%	1,17%	1,11%
6	551	637	2,26%	2,36%	1,08%
7	461	550	4,53%	4,66%	4,07%
8	366	460	9,05%	9,08%	8,84%
9		365	18,10%	20,33%	20,25%

Validation of Calibration

- The calibration of the scoring system which is another important task in scoring model validation.
  - **The first group of tests** can only be applied to one single rating grade over a single time period *(binomial test Clopper and Pearson, binomial test Agresti and Coulla, binomial test Wald , corrected binomial test Wald, binomial test Wilson, corrected binomial test Wilson, one-factor-model, moment matching approach and granularity adjustment)*
  - **The second group of tests** provide more advanced methods that can be used to test the adequacy of the default probability prediction over a single time period for several rating grades (*Spiegelhalter test, Hosmer-Lemeshow test, Blöchlinger test*).

Migration Matrix

Rating 31/31/2010	Rating 31/31/2011									
	1	2	3	4	5	6	7	8	9	
1	0	1	0	0	0	0	0	0	0	1
	0%	100%	0%	0%	0%	0%	0%	0%	0%	100%
2	0	49	19	10	4	3	0	0	0	85
	0%	57,65%	22,35%	11,76%	4,71%	3,53%	0%	0%	0%	100%
3	0	20	92	52	35	11	3	1	0	214
	0%	9,35%	42,99%	24,30%	16,36%	5,14%	1,40%	0,47%	0%	100%
4	0	5	46	130	87	69	14	8	1	360
	0%	1,39%	12,78%	36,11%	24,17%	19,17%	3,89%	2,22%	0,28%	100%
5	0	0	14	73	180	159	68	17	3	514
	0%	0%	2,72%	14,20%	35,02%	30,93%	13,23%	3,31%	0,58%	100%
6	0	1	6	29	109	265	218	78	24	730
	0%	0,14%	0,82%	3,97%	14,93%	36,30%	29,86%	10,68%	3,29%	100%
7	0	0	1	3	24	134	394	207	65	828
	0%	0%	0,12%	0,36%	2,90%	16,18%	47,58%	25%	7,85%	100%
8	0	0	0	1	9	40	114	364	176	704
	0%	0%	0%	0,14%	1,28%	5,68%	16,19%	51,70%	25%	100%
9	0	0	0	1	1	3	26	90	323	444
	0%	0%	0%	0,23%	0,23%	0,68%	5,86%	20,27%	72,75%	100%

+1	+2	+3	+4	+5	+6	+7	+8	+	
0	26	67	107	143	177	140	90	750	worsened ratings
0,00%	0,67%	1,73%	2,76%	3,69%	4,56%	3,61%	2,32%	19,33%	
-1	-2	-3	-4	-5	-6	-7	-8	-	
1	19	62	126	242	303	311	269	1333	
0,03%	0,49%	1,60%	3,25%	6,24%	7,81%	8,02%	6,93%	34,36%	improved ratings

Conclusions

- Assessment of Credit Risk of Companies by Central Banks important for many reasons, a.o. for:
  - Banking Supervision and Evaluation of Financial Stability,
  - Assessment of Credit Quality of Collateral

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