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IBAR - Impact of Accounting Ratios on Bank Ratings

Diploma thesis of Patrick Haverkate in cooperation with the "Landesbank Baden-Württemberg"

Eurobanking 2010
Utrecht – May 17, 2010

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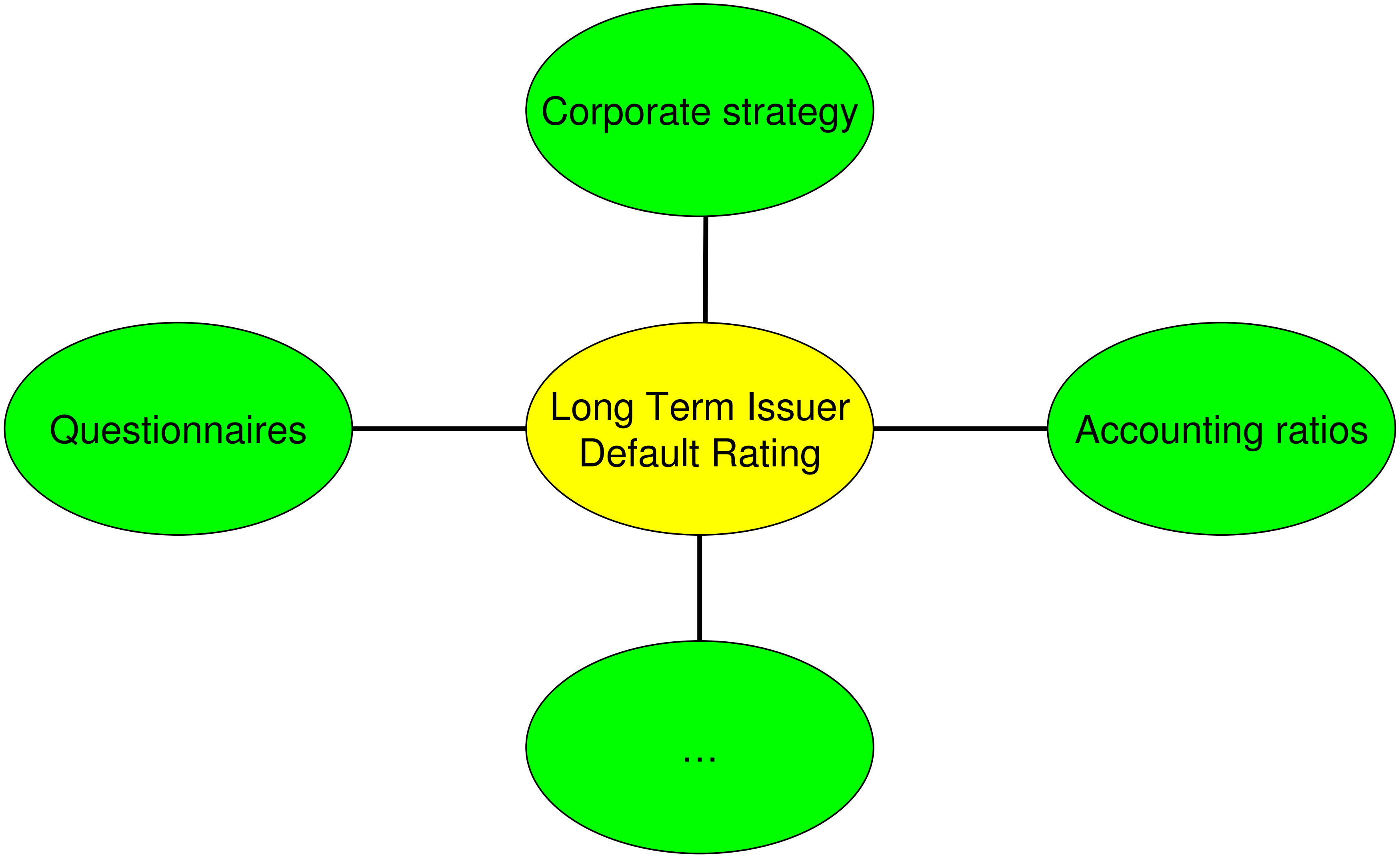
Motivation

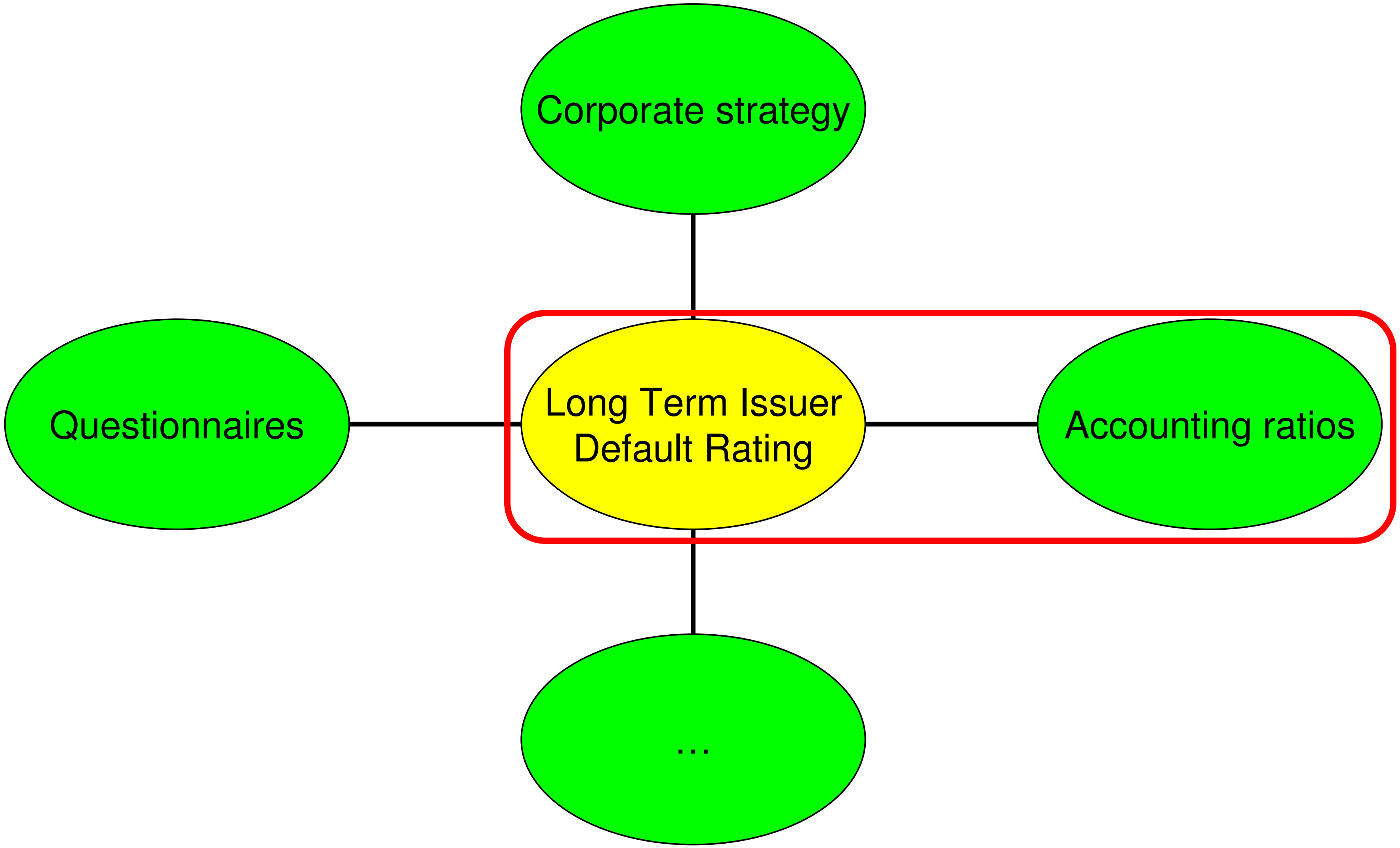
Fitch's Long Term Issuer Default Rating

- assigned to all important companies / banks in every sector and every cluster
- strong interrelation to the default rate
- rating classes AAA, AA, ..., C

Motivation


Corporate strategy
Questionnaires
Long Term Issuer Default Rating
Accounting ratios
…

Motivation


Corporate strategy
Questionnaires
Long Term Issuer Default Rating
Accounting ratios
…

Motivation

- determination of the impact of 9 accounting ratios
  on Fitch's Long Term Issuer Default Rating
- separate analyses for 3 countries
  → USA
  → Spain
  → Germany
- static bank data 2006

Motivation

9 accounting ratios

- Number of Employees
- Total Assets
- ROAA (Return on Average Assets)
- ROAE (Return on Average Equity)
- Regulatory Tier 1 Ratio
- Net Impaired Loans / Equity
- Cost / Income
- Loan Growth
- Net Interest Margin

Data

Fitch Peer Anaylsis Report 2007

- includes identification characteristics, rating grades and accounting ratios of banks of one country for 2006
- includes 10 different ratings and 86 balance sheet ratios
- 36 banks in the USA
- 45 banks in Spain
- 20 banks in Germany
- all rating grades available
- accounting ratios with missing values

  → 2 ratios in the USA

  → 1 ratio in Spain

  → 4 ratios in Germany

Statistical methods

Multiple regression model

- $y = X\beta + \varepsilon$
- assumptions:

→ n > k + 1 (more observations than unknown parameters)

→ X has full column rank

→ $\varepsilon \sim N\left(0, \sigma^2 I_n\right)$

i.e. the residuals are normal distributed, homoscedastic and independant

→ ordinary least squares estimator:

$$\hat{\beta} = \left(X^T X\right)^{-1} X^T y$$

Statistical methods

Proportional odds model

- ordinal target variable with values 1,…,L
- $$logit(P(Y \leq l)) = \alpha_l + \beta_1 X_1 + \ldots + \beta_k X_k$$

$$\Leftrightarrow P(Y \leq l) = \frac{\exp(\alpha_l + \beta_1 X_1 + \ldots + \beta_k X_k)}{1 + \exp(\alpha_l + \beta_1 X_1 + \ldots + \beta_k X_k)} \quad \forall l \in \{1, \ldots, L-1\}$$

- determination of the estimators by numerical procedures

Handling of missing values

- fitting multiple regression models
- target values: accounting ratios with missing values
- every entirely filled accounting ratio in the data set and its logarithm (if computable) are possible influence factors
- sorting out of inappropriate accounting ratios
- selection of the model variables on basis of the adjusted coefficient of determination
  -> forward and backward selection

Statistical analyses (multiple regression model)

Preliminary considerations

- Fitch's Long Term Issuer Default Rating ordinal

  -> transformation into a cardinal scaled variable necessary

- strong interrelation between Fitch's Long Term Issuer Default Rating and default rate

  -> new target value: logarithmised default rate over 5 years

rating class	AAA	AA	A	BBB	BB	B	CCC bis C
5-year default rate	0.0000	0.0006	0.0073	0.0347	0.0984	0.1116	0.4341

Statistical analyses (multiple regression model)

Refinement of the default rates

Examples:

$$DR_{A+} = DR_A - \frac{1}{3}\left(DR_A - DR_{AA}\right)$$

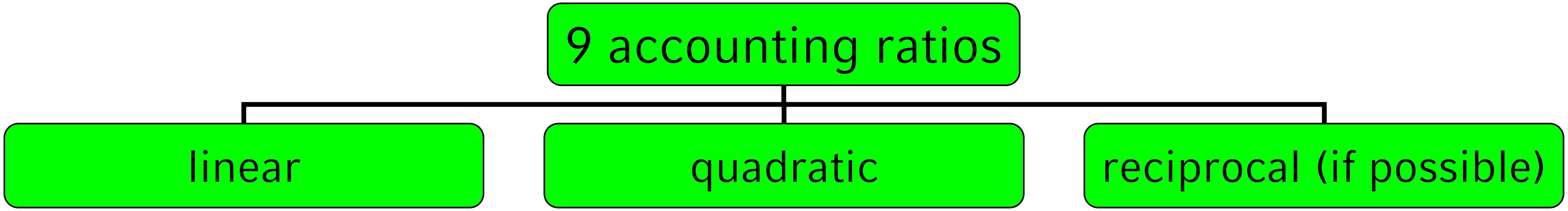
$$= 0.0073 - \frac{1}{3}\left(0.0073 - 0.0006\right) \approx 0.0051$$

$$DR_{A-} = DR_A + \frac{1}{3}\left(DR_{BBB} - DR_A\right)$$

$$= 0.0073 + \frac{1}{3}\left(0.0347 - 0.0073\right) \approx 0.0164$$

Statistical analyses (multiple regression model)

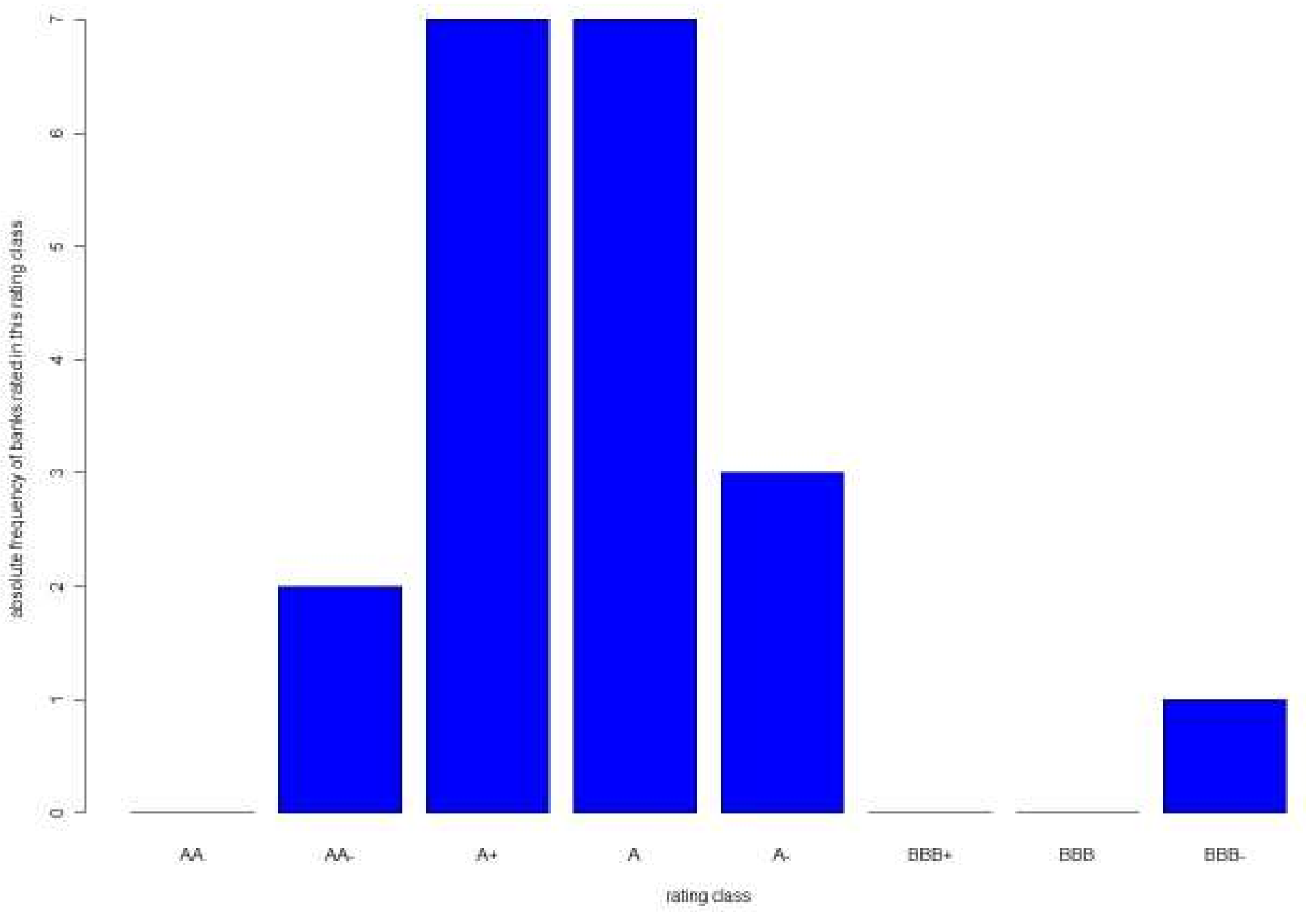
Possible influencing variables



Forward and backward selection on basis of Akaike‘s Information criterion (AIC)

Statistical analyses (multiple regression model)

Distribution of rating classes in Germany



Statistical analyses (multiple regression model)

Impact analysis Germany

- increasing probability of default with greater values for:

  -> Number of Employees

  -> Net Impaired Loans / Equity

  -> ROAE

  -> Regulatory Tier 1 Ratio

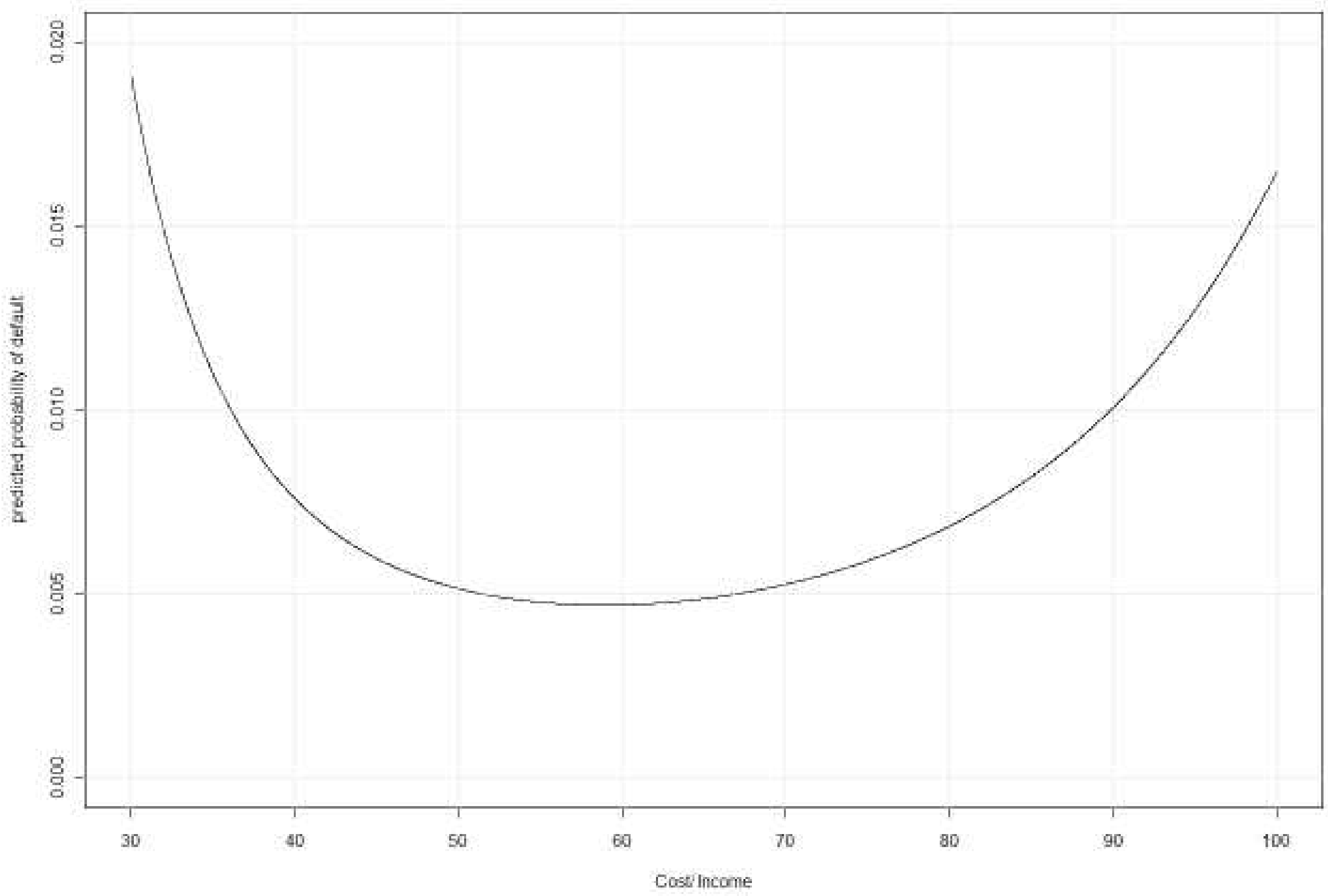
- decreasing probability of default with greater values for:

  -> ROAA

  -> Total Assets

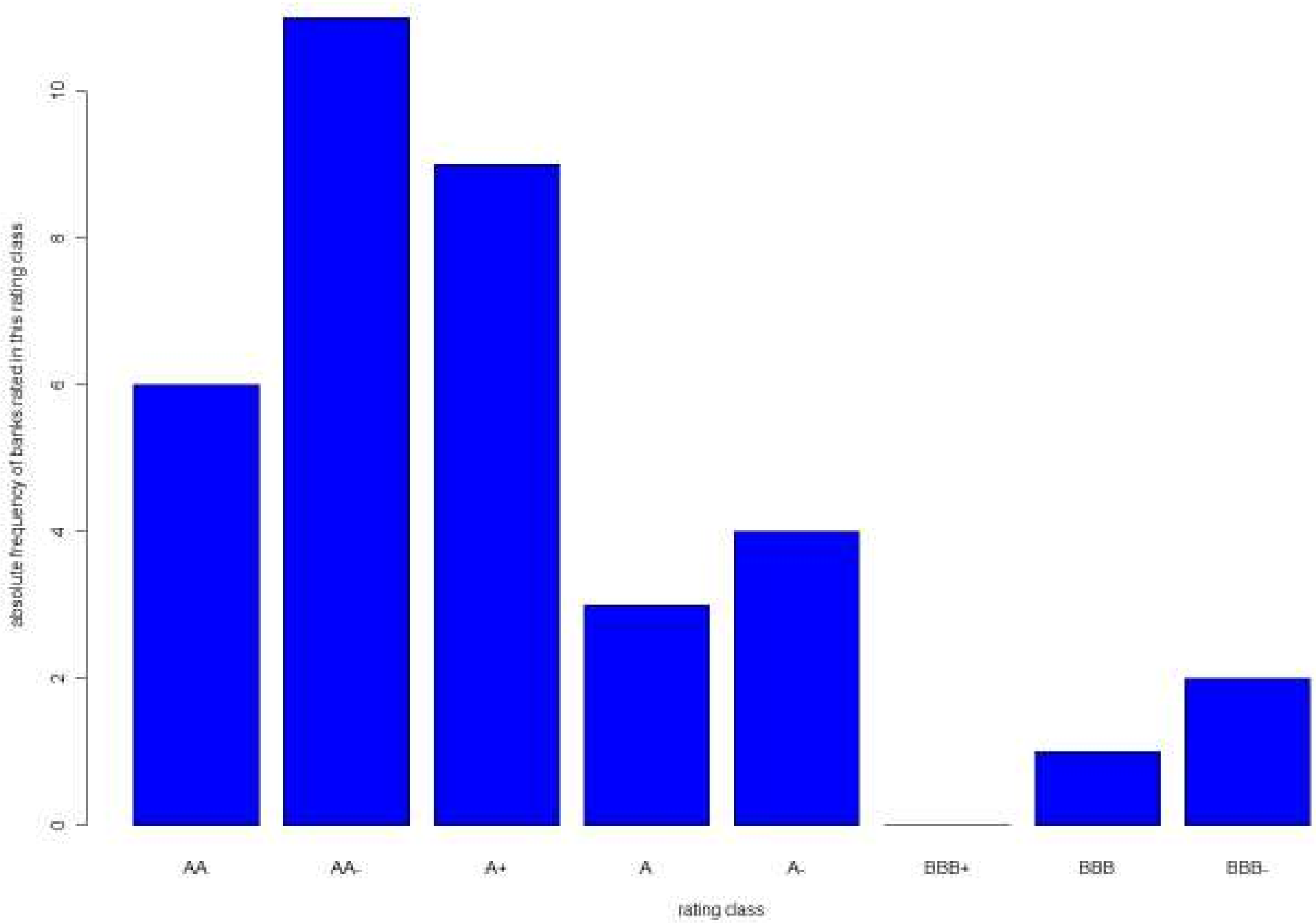
Statistical analyses (multiple regression model)

Influence of Cost / Income in the German multiple regression model



Statistical analyses (multiple regression model)

Distribution of rating classes in the USA



Statistical analyses (multiple regression model)

Impact analysis USA

- increasing probability of default with greater values for:

  -> Loan Growth

  -> Net Impaired Loans / Equity

  -> Number of Employees (0 – 60000)

- decreasing probability of default with greater values for:

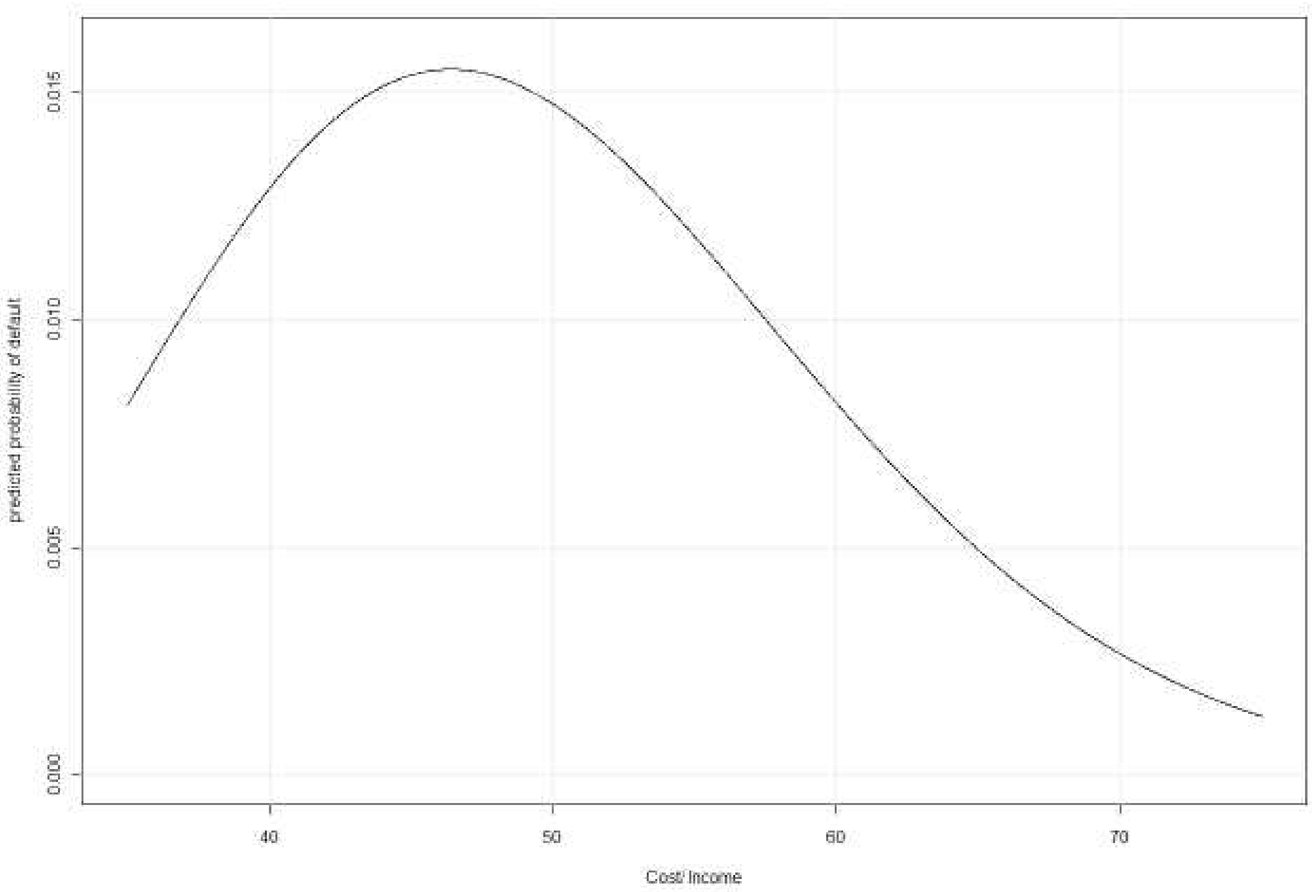
  -> ROAA

  -> Total Assets

  -> Number of Employees (> 60000)

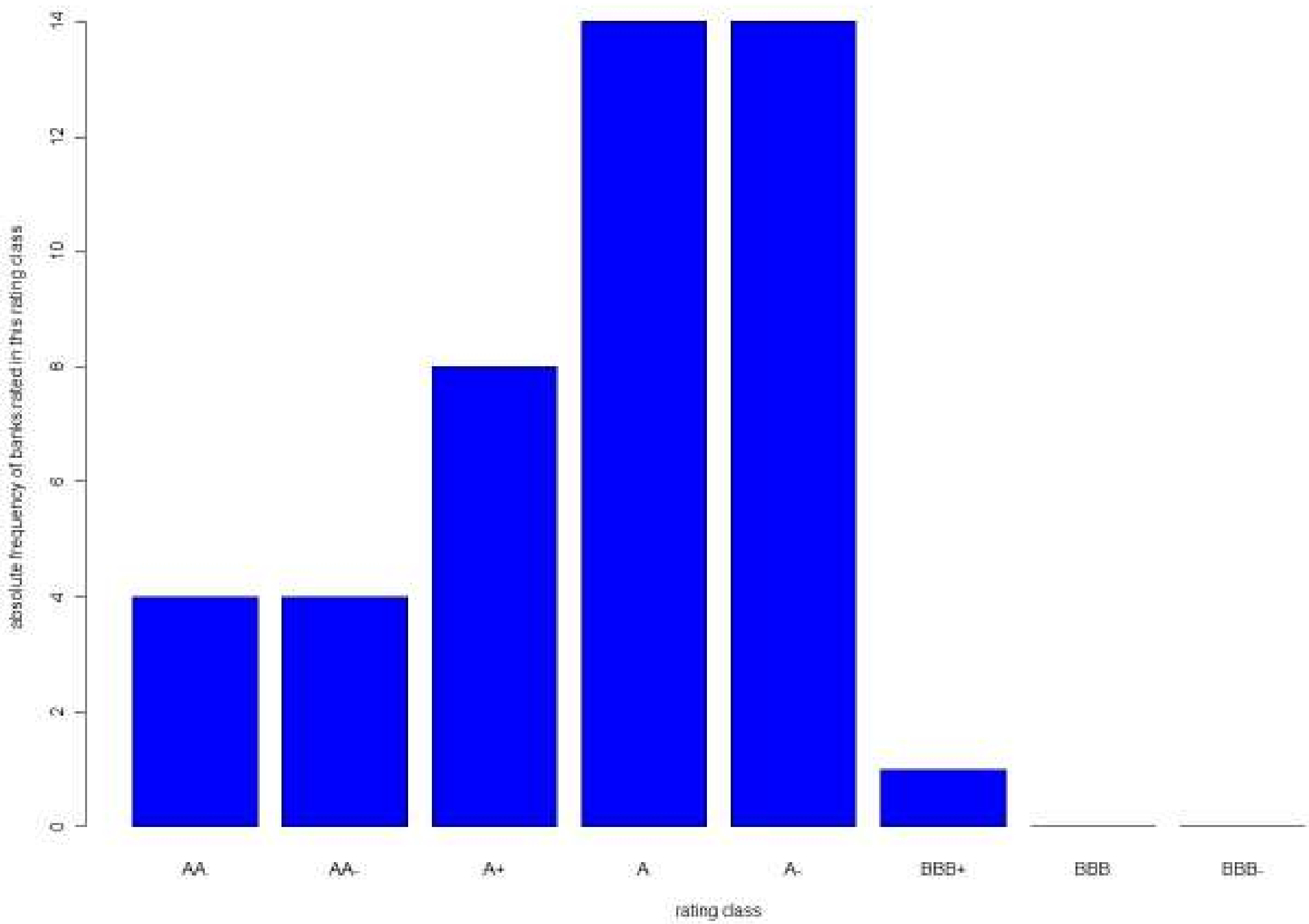
Statistical analyses (multiple regression model)

Influence of Cost / Income in the American multiple regression model



Statistical analyses (multiple regression model)

Distribution of rating classes in Spain



Statistical analyses (multiple regression model)

Impact analysis Spain

- increasing probability of default with greater values for:

  -> Cost / Income

  -> Loan Growth

  -> Number of Employees

- decreasing probability of default with greater values for:

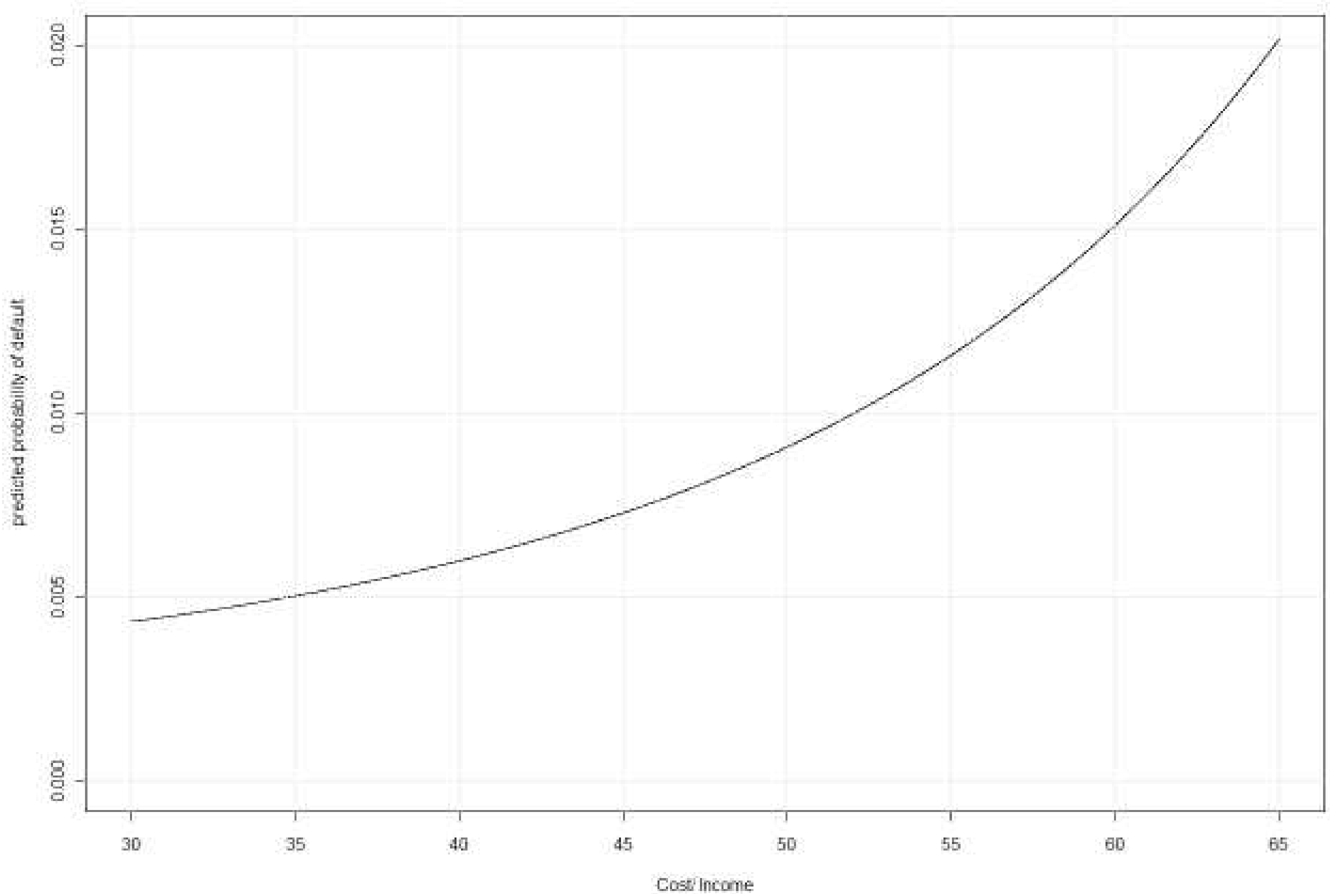
  -> Net Impaired Loans / Equity

  -> ROAE

  -> Total Assets

Statistical analyses (multiple regression model)

Influence of Cost / Income in the Spanish multiple regression model



Statistical analyses (multiple regression model)

Country Comparison

Commonnesses	Differences
Net Interest Margin without influence	number and kind of the regressors
high values of Total Assets lead to lower predicted probabilities of default	most balance sheet ratios have different influences on the probability of default
Regulatory Tier 1 Ratio and Loan Growth have no or just negligible influence	different strengths of the effects
	range of Net Impaired Loans/ Equity

Statistical analyses (proportional odds model)

Preliminary considerations

- Motivation

  - default rate over 5 years not appropriate for all banks

  - default rates of the "+" and "-"-nuances of a category have been selected arbitrarily

- Proportional odds model

  - Fitch's Long Term Issuer Default Rating as target variable possible

  - probabilities determinable for rating classes

Statistical analyses (proportional odds model)

Impact analysis Germany

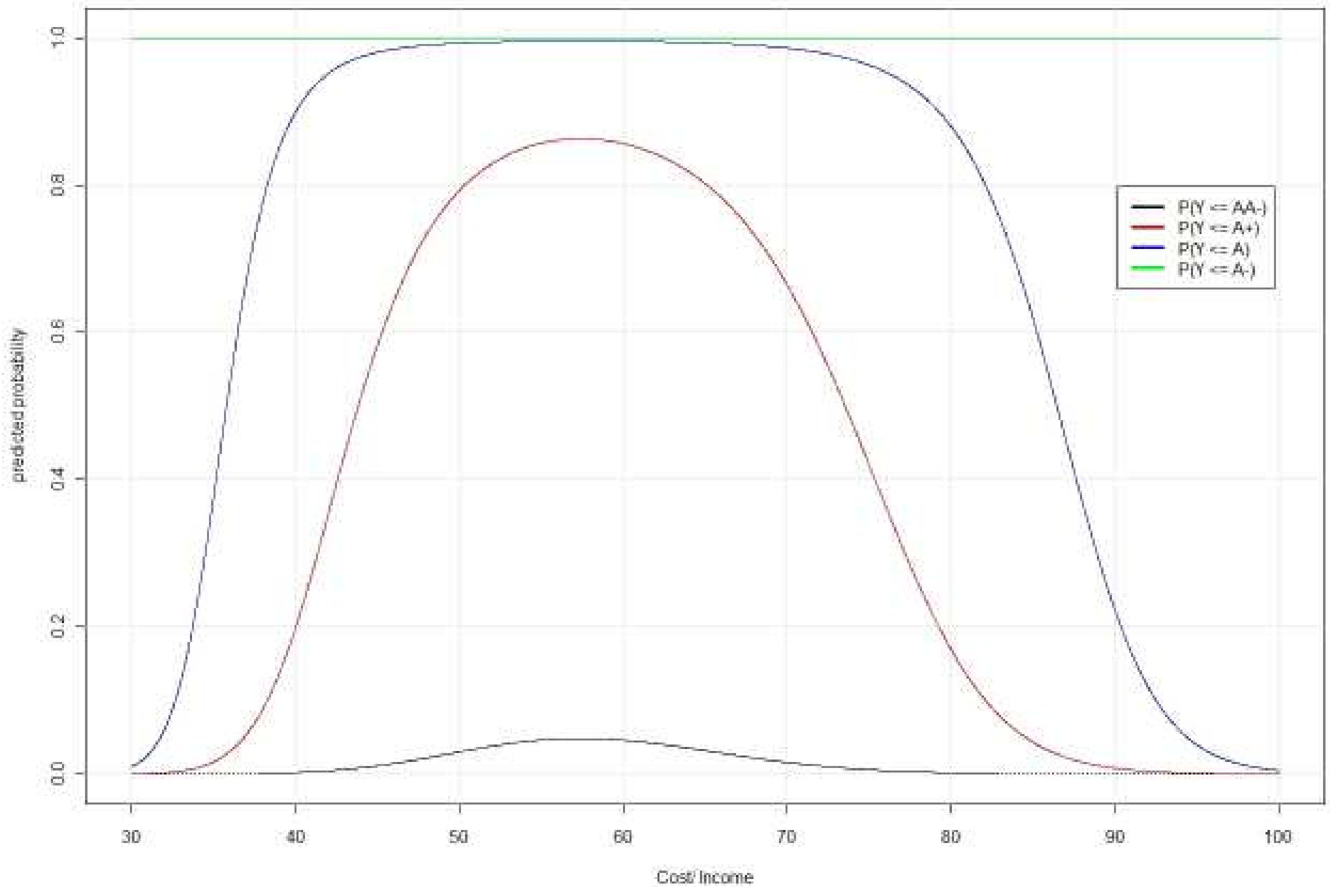
- decreasing probabilities with greater values , i.e. lower values are better for:

  -> Net Impaired Loans / Equity

  -> ROAE

Statistical analyses (proportional odds model)

Influence of Cost / Income in the German proportional odds model



Statistical analyses (proportional odds model)

Impact analysis USA

- increasing probabilities with greater values for:

  -> Number of Employees

  -> Regulatory Tier 1 Ratio

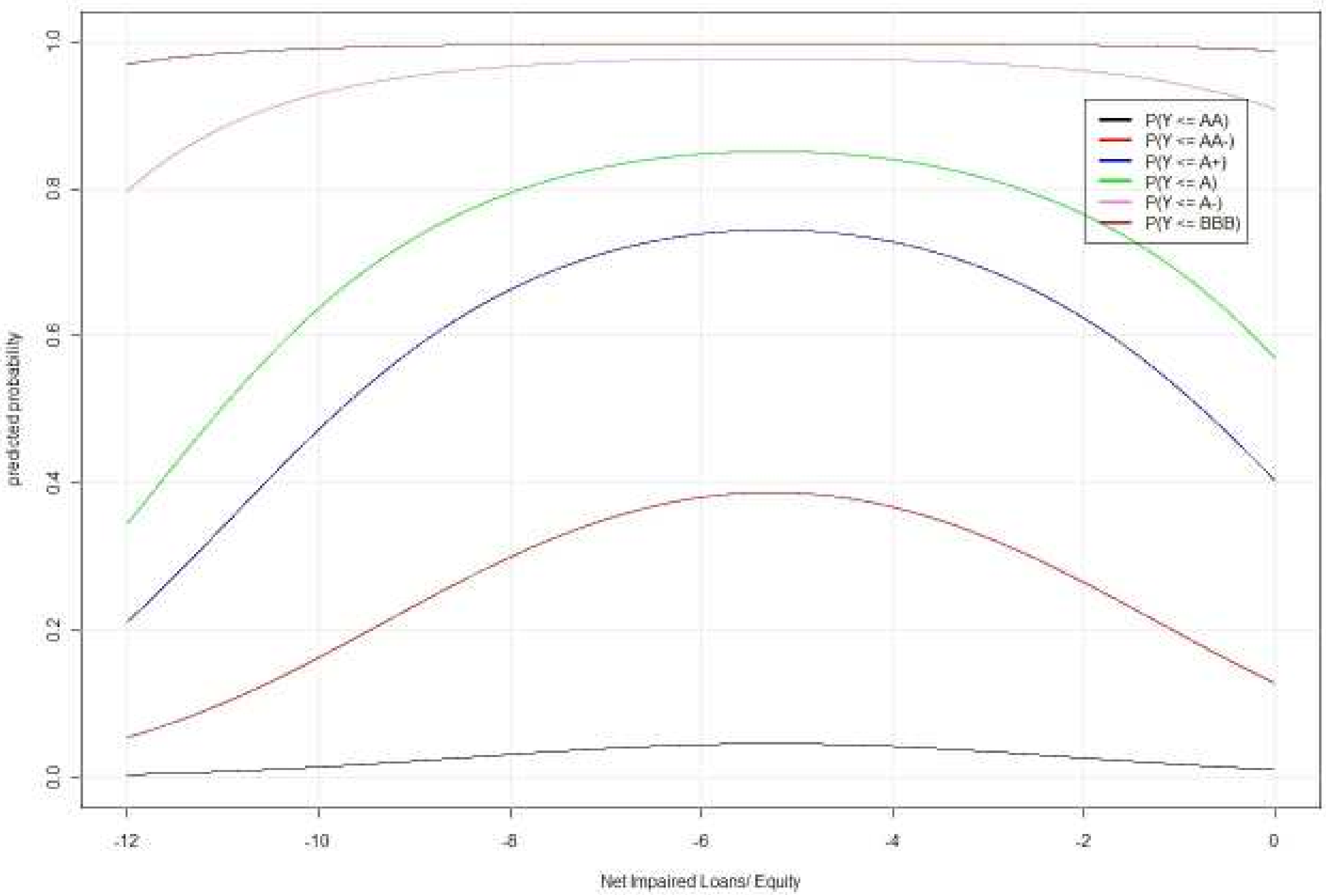
  -> ROAA

- decreasing probabilities with lower values for:

  -> Total Assets

Statistical analyses (proportional odds model)

Influence of Net Impaired Loans / Equity in the American proportional odds model



Statistical analyses (proportional odds model)

Impact analysis Spain

- increasing probabilities with greater values for:

  -> Net Impaired Loans / Equity

  -> ROAA

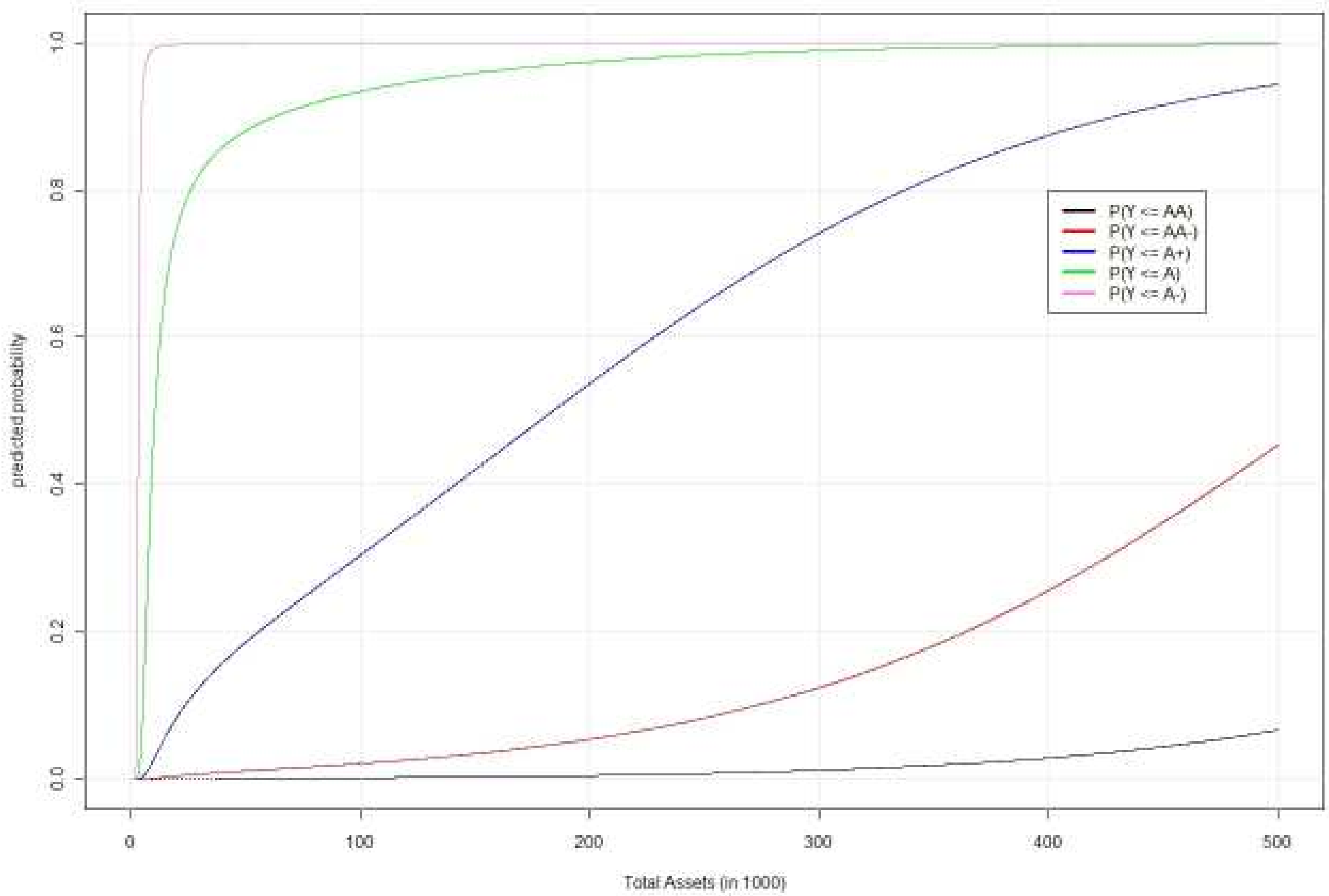
  -> Total Assets

- decreasing probabilities with lower values for:

  -> Cost / Income

Statistical analyses (proportional odds model)

Influence of Total Assets in the Spanish proportional odds model



Statistical analyses (proportional odds model)

Country Comparison

Commonnesses	Differences
Net Interest Margin and Loan Growth without influence	number and kind of the regressors
negligible influence of Number of Employees and ROAE	most balance sheet ratios have different influences on the probability of default
	different strengths of the effects
	range of Net Impaired Loans/ Equity

Summary

Peculiarities

- Net Interest Margin without and Loan Growth with negligible influence
- rating changes in terms for different values of Net Impaired Loans / Equity and Cost / Income
- high values for Total Assets have generally a positive effect on the rating
- Number of Employees strong influence factor on the default rate
- models are not transferable from one country to another

Summary

Model selection

- Advantages of the multiple regression model
  - default of a bank is of interest
  - (very) good fits of the linear models (coefficient of determination)
  - can be applied to predict defaults of a bank
- Advantages of the proportional odds model
  - no transformation of the target variable necessary
  - suitable to predict rating changes
  - consideration of the probabilities of rating classes (further influence factors)

IBAR –
Impact of Accounting Ratios on Bank Ratings

- Annex -

Eurobanking 2010
May 17, 2010

Backup-Info

Data

Extraction of the Fitch Peer Analysis Report for Germany

Bank	LTIDR	ROAA	Loan Growth	NoE	...
Aareal Bank AG	A-	0.32	-4.20	2712	...
Bayerisch LB	A+	0.33	3.60	9723	...
Commerzbank AG	A	0.34	93.30	35975	...
Deutsche Bank AG	AA-	0.39	-	21490	...
EUROHYPO AG	A	0.19	-7.50	-	...
SEB AG	A+	0.28	-12.40	3836	...
WestLB AG	A-	0.28	17.80	5862	...
⋮	⋮	⋮	⋮	⋮	

Backup-Info

Statistical methods (multiple regression model)

$$y = X\beta + \varepsilon$$

$y = (y_1, \ldots, y_n)^T$ **-> observable vector of the dependent variable**

$\beta = (\beta_0, \beta_1, \ldots, \beta_k)^T$ **-> unknown parameter vector**

$\varepsilon = (\varepsilon_1, \ldots, \varepsilon_n)^T$ **-> residual vector**

$$X = \begin{pmatrix} 1 & x_{11} & \cdots & x_{k1} \\ 1 & x_{12} & \cdots & x_{k2} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_{1n} & \cdots & x_{kn} \end{pmatrix}$$

-> model matrix: includes the observed values of the k independent variables

Backup-Info

Statistical methods (multiple regression model)

Check of the assumptions regarding the residuals

by viewing graphics

- Fitted vs. Residuals to check the homoscedasticity and the independence
- Normal-QQ-Plot to check normal distribution assumption

Backup-Info

Statistical methods (multiple regression model)

Distribution of the ordinary least squares estimator:

$$\hat{\beta} \sim N\left(\beta, \sigma^2 \left(X^T X\right)^{-1}\right),$$

if the assumptions of the residual vector hold true.

-> confidence interval for $\hat{\beta}$:

$$KI_{\beta_h}(1-\theta) = \left(\hat{\beta}_h - s\sqrt{c_{hh}}\, t_{n-k-1;1-\theta/2}, \hat{\beta}_h + s\sqrt{c_{hh}}\, t_{n-k-1;1-\theta/2}\right)$$

s – standard deviation

t_{n-k-1} - is the $(1-\theta/2)$-quantile of the t-distribution with n-k-1 degrees of freedom

c_{hh}- is the h-th element of the diagonal of $\left(X^T X\right)^{-1}$

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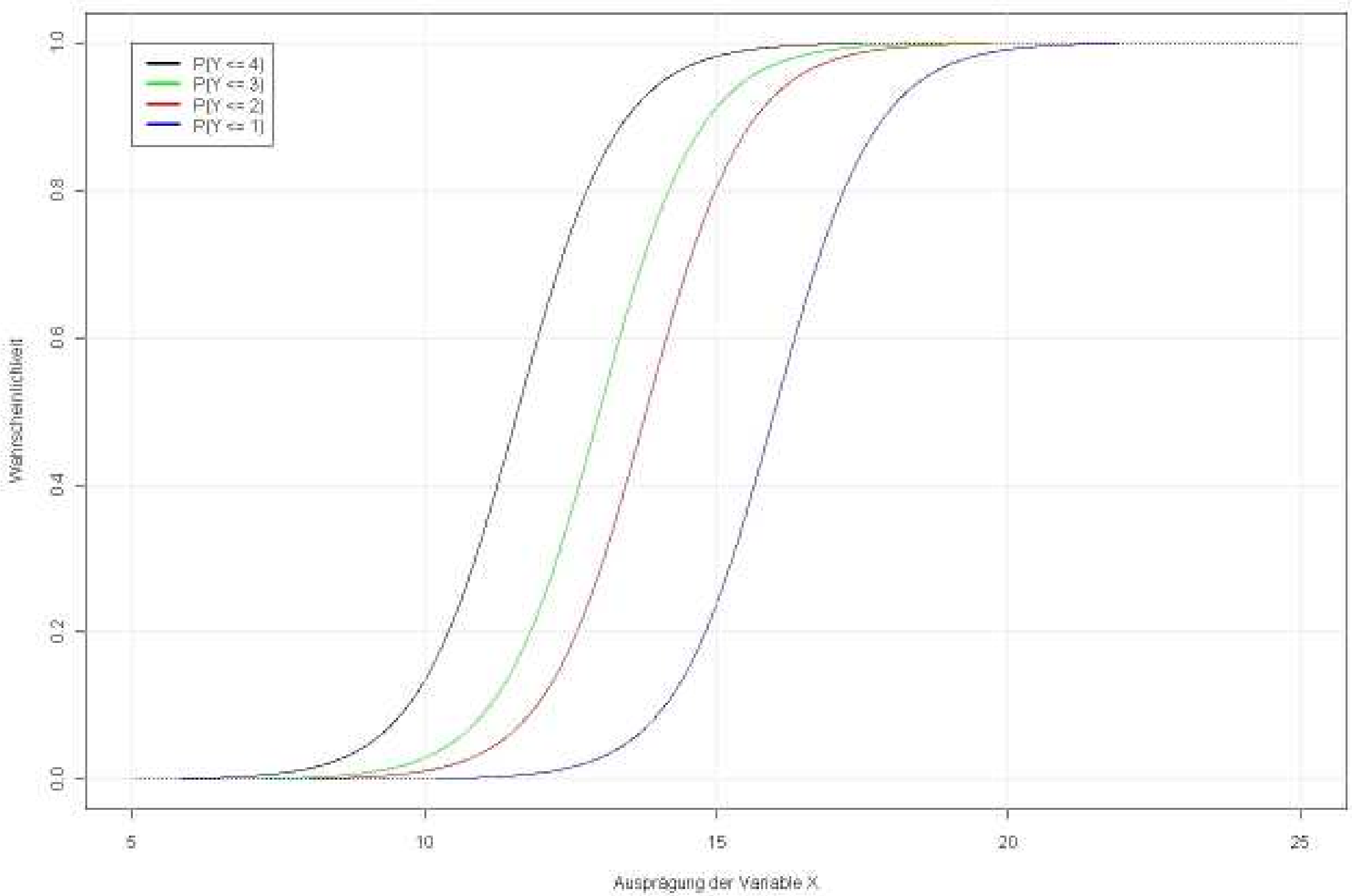
Statistical methods (proportional odds model)

Graphical example: target variable has 5 categories; 1 linear influence factor



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Statistical methods (proportional odds model)

Parameter estimator in the proportional odds model

- no formal version of the estimator existent
- to determine by the likelihood-function
- to determine by numerical procedures, e.g. Newton-Raphson
- approximative normal distribution of the parameter estimator

$$KI_{\alpha_l}(1-\theta) = \left(\hat{\alpha}_l - u_{1-\theta/2} s_{\hat{\alpha}_l}, \hat{\alpha}_l + u_{1-\theta/2} s_{\hat{\alpha}_l}\right)$$

resp.

$$KI_{\beta_h}(1-\theta) = \left(\hat{\beta}_h - u_{1-\theta/2} s_{\hat{\beta}_h}, \hat{\beta}_h + u_{1-\theta/2} s_{\hat{\beta}_h}\right)$$

with $u_{1-\theta/2}$ being the $(1-\theta/2)$-quantile of the standard normal distribution

Backup-Info

Handling of missing values

- every entirely filled accounting ratio in the data set and its logarithm (if computable) are possible influence factors
  -> for the USA 79 possible influence variables
  -> for Spain 107 possible influence variables
  -> for Germany 68 possible influence variables
- model basis for the forward and backward selection: model with no influence variable
- in 4 out of 7 cases this method delivers plausible results

Backup-Info

Handling of missing values

- amendments of other models
  - taking the logarithm of the target value (if possible) and/or
  - model without intercept and/or
  - reduction of the amount of suitable influence variables

Backup-Info

Handling of missing values

Example

- standard procedure delivers the following estimates

  - for COREALCREDIT BANK AG: -9540

  - for EUROHYPO AG: 5043

  - for Genossenschaftlicher Finanzverbund: 177139

  -> these results are considered as implausible

Backup-Info

Handling of missing values

Example

- standard procedure without intercept delivers the following estimates
  - for COREALCREDIT BANK AG: -4013
  - for EUROHYPO AG: 8915
  - for Genossenschaftlicher Finanzverbund: 175470

-> these results are considered as implausible

Backup-Info

Handling of missing values

Example

- standard procedure with logarithmised target variable delivers the following estimates
  - for COREALCREDIT BANK AG: 372
  - for EUROHYPO AG: 26987
  - for Genossenschaftlicher Finanzverbund: 619467

  -> these results are considered as implausible

Backup-Info

Handling of missing values

Example

- standard procedure with logarithmised target variable and without intercept delivers the following estimates
  - for COREALCREDIT BANK AG: 612
  - for EUROHYPO AG: 4342
  - for Genossenschaftlicher Finanzverbund: 20023
  -> these results are considered as plausible

Backup-Info

Statistical analyses (multiple regression model)

Impact analysis Germany

X_j	Influence factor	$\hat{\beta}_j$	0.025-limit	0.975-limit
	Intercept	$\hat{\beta}_0$ = -8.77	-10.96	-6.58
X_1	(Cost/ Income)²	$\hat{\beta}_1$ = 0.000341	0.000207	0.000476
X_2	1/(Cost/ Income)	$\hat{\beta}_2$ = 139.2	72.21	206.15
X_3	1/(Net Impaired Loans/ Equity)	$\hat{\beta}_3$ = -3.999	-6.622	-1.377
X_4	Number of Employees	$\hat{\beta}_4$ = 0.0000161	-0.00000438	0.0000367
X_5	1/(Number of Employees)	$\hat{\beta}_5$ = -180.3	-410.7	50.1
X_6	1/(Regulatory Tier 1 Ratio)	$\hat{\beta}_6$ = -5.226	-15.53	5.07
X_7	(ROAA)²	$\hat{\beta}_7$ = -1.087	-2.82	0.651
X_8	ROAE	$\hat{\beta}_8$ = 0.0768	0.0389	0.115
X_9	(ROAE)²	$\hat{\beta}_9$ = -0.000783	-0.0017	0.00013
X_{10}	(Total Assets)²	$\hat{\beta}_{10} = -4.16 \cdot 10^{-13}$	$-9.25 \cdot 10^{-13}$	$9.22 \cdot 10^{-14}$
X_{11}	1/(Total Assets)	$\hat{\beta}_{11}$ = 44180	18022	70334

$$model: \hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 X_1 + \ldots + \hat{\beta}_{11} X_{11}$$

Backup-Info

Statistical analyses (multiple regression model)

Impact analysis USA

X_j	Influence factor	$\hat{\beta}_j$	0.025-limit	0.975-limit
	Intercept	$\hat{\beta}_0 = 3.734$	-5.27	12.74
X_1	(Cost/ Income)²	$\hat{\beta}_1 = -0.00136$	-0.00241	-0.000308
X_2	1/(Cost/ Income)	$\hat{\beta}_2 = -271.9$	-598.8	55.1
X_3	1/(Loan Growth)	$\hat{\beta}_3 = -0.5225$	-1.123	0.0775
X_4	Net Impaired Loans/ Equity	$\hat{\beta}_4 = 0.1977$	0.111	0.284
X_5	1/(Net Impaired Loans/ Equity)	$\hat{\beta}_5 = 0.02734$	-0.0175	0.0722
X_6	Number of Employees	$\hat{\beta}_6 = -0.00000561$	-0.00000982	-0.000014
X_7	1/(Number of Employees)	$\hat{\beta}_7 = -19470$	-26920	-12016
X_8	1/(ROAA)	$\hat{\beta}_8 = 0.9983$	0.561	1.44
X_9	1/(Total Assets)	$\hat{\beta}_9 = 145400$	75530	215245

$$model: \quad \hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 X_1 + \ldots + \hat{\beta}_9 X_9$$

Backup-Info

Statistical analyses (multiple regression model)

Impact analysis Spain

X_j	Influence factor	$\hat{\beta}_j$	0.025-limit	0.975-limit
	Intercept	$\hat{\beta}_0$ = -4.927	-5.801	-4.053
X_1	(Cost/ Income)²	$\hat{\beta}_1$ = 0.000462	0.000248	0.000675
X_2	1/(Loan Growth)	$\hat{\beta}_2$ = -2.626	-5.839	0.586
X_3	(Net impaired Loans/ Equity)²	$\hat{\beta}_3$ = 0.00107	-0.000559	0.0026
X_4	1/(Net Impaired Loans/ Equity)	$\hat{\beta}_4$ = 2.643	0.263	5.022
X_5	(Number of Employees)²	$\hat{\beta}_5 = 1.865 \cdot 10^{-10}$	$4.63 \cdot 10^{-12}$	$3.68 \cdot 10^{-10}$
X_6	ROAE	$\hat{\beta}_6$ = -0.07975	-0.1145	-0.0445
X_7	Total Assets	$\hat{\beta}_7$ = -0.00000579	-0.00000973	-0.00000184

$$model: \quad \hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 X_1 + \ldots + \hat{\beta}_7 X_7$$

WestLB

Backup-Info

Statistical analyses (proportional odds model)

Impact analysis Germany

X_j	Influence factor	$\hat{\beta}_j$	0.025-limit	0.975-limit
X_1	(Cost/ Income)²	$\hat{\beta}_1 = -0.00276$	-0.00486	-0.00066
X_2	1/(Cost/ Income)	$\hat{\beta}_2 = -1043.381$	-1776.711	-310.051
X_3	1/(Net Impaired Loans/ Equity)	$\hat{\beta}_3 = 28.77$	6.718	50.836
X_4	ROAE	$\hat{\beta}_4 = -0.1905$	-0.3878	0.0068

$$Model: \quad logit\left(\hat{P}(Y \leq l)\right) = \hat{\alpha}_l + \hat{\beta}_1 X_1 + \ldots + \hat{\beta}_4 X_4$$

Backup-Info

Statistical analyses (proportional odds model)

Impact analysis USA

X_j	Influence factor	$\hat{\beta}_j$	0.025-limit	0.975-limit
X_1	Net Impaired Loans/ Equity	$\hat{\beta}_1 = -0.553$	-1.2	0.094
X_2	(Net Impaired Loans/ Equity)²	$\hat{\beta}_2 = -0.0525$	-0.119	0.0145
X_3	(Number of Employees)²	$\hat{\beta}_3 = 5.26 \cdot 10^{-10}$	$-2.599 \cdot 10^{-10}$	$1.312 \cdot 10^{-9}$
X_4	(Regulatory Tier 1 Ratio)²	$\hat{\beta}_4 = 0.0328$	0.0104	0.0552
X_5	1/(ROAA)	$\hat{\beta}_5 = -1.403$	-2.729	-0.077
X_6	(Total Assets)²	$\hat{\beta}_6 = -6.91 \cdot 10^{-12}$	$-1.931 \cdot 10^{-11}$	$5.496 \cdot 10^{-12}$

$$model: \quad logit\left(\hat{P}(Y \leq l)\right) = \hat{\alpha}_l + \hat{\beta}_1 X_1 + \ldots + \hat{\beta}_6 X_6$$

Backup-Info

Statistical analyses (proportional odds model)

Impact analysis Spain

X_j	Influence factor	$\hat{\beta}_j$	0.025-limit	0.975-limit
X_1	Cost/ Income	$\hat{\beta}_1 = -0.181$	-0.291	-0.069
X_2	1/(Net Impaired Loans/ Equity)	$\hat{\beta}_2 = -6.078$	-13.444	1.288
X_3	$(ROAA)^2$	$\hat{\beta}_3 = 1.996$	0.725	3.267
X_4	Total Assets	$\hat{\beta}_4 = 0.00000869$	0.000000693	0.0000167
X_5	1/(Total Assets)	$\hat{\beta}_5 = -21470$	-36653	-6286

$$model: \quad logit\left(\hat{P}(Y \le l)\right) = \hat{\alpha}_l + \hat{\beta}_1 X_1 + \ldots + \hat{\beta}_5 X_5$$