Predicting bank rating transitions using optimal competing risks survival analysis models

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Outline

Motivation

Predicting bank rating transitions using optimal competing risks survival analysis models

- Late-2000's financial crisis
- Ongoing debate on capital ratios, stress tests, etc.

- Academic literature mainly focuses on corporates

$\Rightarrow$ Improve the understanding of the causes of changes in credit quality

$\Rightarrow$ Focus on the prediction of credit rating migrations and the identification of potential problem banks

$\Rightarrow$ Early warning model?

Background information

- Earliest literature:
  - $\Rightarrow$ Focusing on the explanation and prediction of bankruptcies of financial institutions
    - Sinkey (1975): Discriminant analysis
    - Martin (1977): Logistic regression
    - Lane *et al.* (1986), Whalen (1991): Cox PH survival analysis
- Failure versus no failure as a function of accounting variables
  - Reliable? Timely?
- Default prediction $\Rightarrow$ rating migration modeling
- Rating change as a function of the state of the macro-economy, idiosyncratic variables, etc.
- Nickell *et al.* (2000); Kavvathas (2000); Lando & Skødeberg (2002); Hamilton & Carter (2004); Duffie *et al.* (2007), Trück (2008); Figlewski *et al.* (2012)

Methodology

- Survival analysis:
  - Outcome variable: time to the occurrence of the event of interest (i.e. rating up- or downgrade)
  - Deals well with censoring

Extended Cox hazard regression model (Cox, 1972)

$$h_i(t, \mathbf{x}(t)) = h_{0i}(t) \exp[\mathbf{x}'(t)\beta_i]$$

Instantaneous potential of a rating event i (e.g. a rating upgrade) during a certain time interval, given that the bank has survived up to t

- Efron approximation
- Clustering: each distinct bank is one cluster

Data

- S&P RatingXpress database
- Sample: January 1994–December 2008
- Time scale: monthly
- Region: USA
- Main rating symbol (i.e. AAA, AA, A, BBB, etc.)

- 755 unique US banks
- 643 rating upgrades and 603 rating downgrades
- Multiple similar events during same month $\Rightarrow$ one event
- Median time to a rating event: $\Uparrow$ 66 months, $\Downarrow$ 81 months

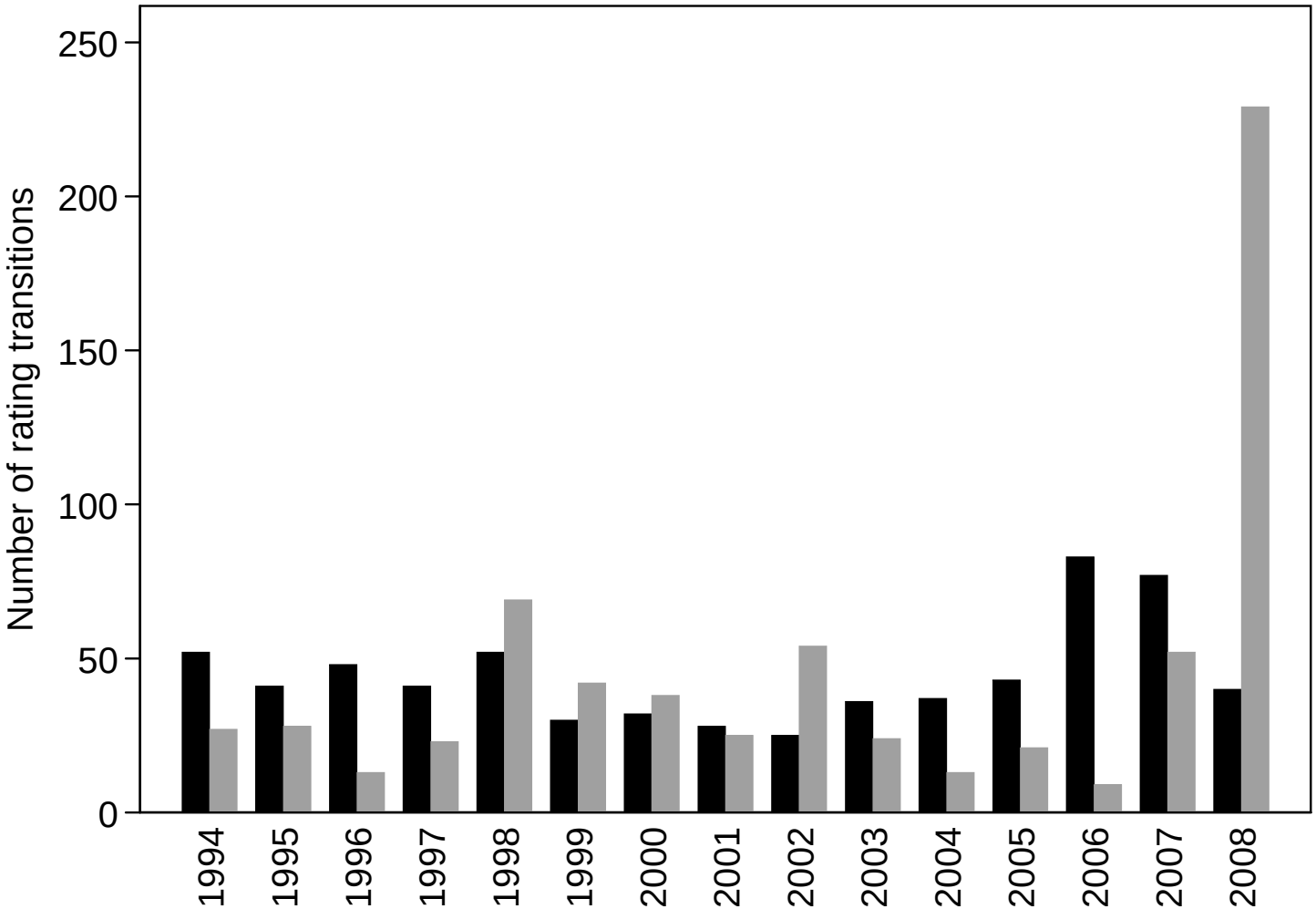

Figure: Number of annual rating transitions. Black bars: # upgrades, gray bars: # downgrades

Covariates

- Recall: we use survival analysis to model the relationship between the outcome variable and a set of covariates
- Two groups:
  - Rating specific covariates
  - Macro-economic covariates

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Rating specific covariates:

Name	Model variable	Base level
Current rating class	Categorical (9=AAA,...,1=D)	BBB
Outlook	Categorical (2=Pos.,1=Stable,0=Neg.)	Stable
# of rating Δ past 24m	Continuous	

Macro-economic covariates

- Three main categories:
  - Current state of the macro-economy
  - Future direction of the macro-economy
  - Current financial market's condition
- When no monthly data was available, monthly estimated were calculated from the different sampling frequencies by fitting a cubic spline curve which is constrained to pass through the datapoints.
- Lagged effects:
  - Influence of the covariates on the rating transition hazard is not instantaneous.
  - Time series data was exponentially filtered.

Macro-economic covariates

Name	Upgrade	Downgrade
Output gap (% of pot. GDP at AR)	+	−
Inflation (CPI-U) (% at SAAR)		
Unemployment rate (% at AR)	−	+
Capacity utilization rate (% at AR)	+	−
Gross national savings (% of GDP at AR)	+	−
Curr. account balance (% of GDP at AR)		
Government gross debt (% of GDP at AR)		
Real GDP growth (% at SAR)	+	−
Bankruptcy filings (Δ% at AR)	−	+
New orders change (Δ% at AR)	+	−
New cars change (Δ% at AR)	+	−
New housing change (Δ% at AR)	+	−
T-bill rate 3m		
Treasury yield adj. to const. maturity 20y		
Prime rate (month avg.)		
Interbank rate 3m (month avg.)	−	+
KBW bank index return	+	−
S&P500 return	+	−

Results

- For both rating events four models were estimated:
  - Full model
  - Backward stepwise model (sig. level: .05)
  - Rating specific covariates only model
  - Macro-economic covariates only model
- Hazard rate calculates the instantaneous rate per unit of time for the event to occur:
  - Negative coefficient reduces the hazard rate (i.e. $HR < 1$)
  - Positive coefficient increases the hazard rate (i.e. $HR > 1$)

Rating specific covariates results

	+ Stepwise	– Stepwise
Current rating symbol: base level BBB		
CC and C	.0226***	.0018***
	(.0208)	(.0022)
CCC	.0033***	.2192**
	(0046)	(.1469)
B	.4527***	.5515
	(.1453)	(.1818)
BB	1.270	1.547
	(.3346)	(.3591)
A	.5863***	.9540
	(.0803)	(.1310)
AA	.5517***	.8982
	(.1027)	(.1357)
AAA		1.034
		(.2507)
Outlook: base level Stable		
Negative	.1033***	5.379***
	(.0512)	(.6415)
Positive	6.4228***	.1928***
	(.8206)	(.0876)
# rating Δ past 24m	12.924***	5.660***
	(1.611)	(.5155)

- Current rating:
  - + model : BBB and BB sig. higher hazard
  - – model : CC and C sig. lower hazard
- Outlook: very significant
- # rating Δ past 24m: very significant $\Rightarrow$ momentum effect

No significant difference full model and rating specific model

Macro-economic covariates results

	+ Stepwise	– Stepwise
Gross national savings	1.286**	.4918***
	(.1248)	(.0647)
Curr. account balance		.7977***
		(.0385)
Government gross debt		3.040***
		(.6855)
T-bill rate 3m	3.421***	
	(.6694)	
Treasury yield		.5621**
		(.1108)
Prime rate		.0953***
		(.0335)
Interbank rate 3m		9.194***
		(3.10)
KBW bank index return		.9664***
		(.0074)

- + model : T-bill rate 3m (+), Gross national savings (+)
- – model : Interbank rate 3m (+), Treasury yield (–), Prime rate (–), KBW bank index return (–), Gross national savings (–), Current account balance (–), Government gross debt (+)

Validation of individual covariates

- Validate results and assess potential predictive power
- Bootstrap sampling with replacements (500 times)
- Wald test
  - H_0: covariate is not significantly helpful in predicting the outcome
- Royston (2006) measure of explained randomness
- Rating specific covariates vital
- Macro-economic covariates most important in rating downgrade model

Model validation

- ROC analysis
- Quantify the discriminative ability of the rating up- and downgrade model by testing whether they are able to correctly classify observations whose rating has changed (i.e. upgraded in + model, downgraded in – model) or not and that adhere to a certain covariate pattern
- Training set: 70%, validation set 30%
- Models were reestimated using the training set and 3 covariates: Outlook, # of rating Δ past 24m, T-bill rate 3m (+), Interbank rate 3m (–).
- Covariate patterns:

Rating upgrade	Covariate patterns	Rating Downgrade	Rating patterns
Outlook	Pos./Stab./Neg.	Outlook	Pos./Stab./Neg.
# of rating Δ past 24m	0 / 1 or more	# of rating Δ past 24m	0 / 1 or more
T-bill rate 3m	≤ 3.91 / > 3.91	Interbank rate 3m	≤ 4.45 / > 4.45

Model validation

- Estimate survival likelihood for each the covariate patterns at arbitrary time horizons: one, two, and four years
- Likelihoods were converted to an ordinal scale, where higher values indicate a lower likelihood.
- Using the validation set: variable captured the true state of the groups with the same covariate patterns
  - + model : rating upgrade versus other
  - – model : rating downgrade versus other
- Area under the ROC curve

Time horizon	Rating upgrade model AUC	Rating Downgrade AUC
One year	0.6410	0.7224
Two years	0.6853	0.6919
Four years	0.6624	0.6530

Summary

- Sig. dependence of rating up- and downgrade transition hazards on rating specific covariates
- Highly speculative banks have lower hazard rates
- Confirm momentum effect
- Rating specific and macro-economic covariates truly capture different information
- Macro-economic covariates more important in the rating downgrade model
- Effect of interest rates twofold
- Validation: both models perform fairly

Future research

- ⇒ Improve the understanding of the causes of changes in credit quality
- ⇒ Focus on the prediction of credit rating migrations and the identification of potential problem banks
- ⇒ Early warning model?

Questions & Answers

Thank you for your attention!

Questions & Answers

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