Session III

Examples of Model Design and Quantification

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Introduction

Case study: corporate rating model

- Intended to assign risk ratings to individual obligors in U.S. corporate portfolio. That is, a classification model, not a (PD) predictive model.
- Through development process – until ready to cut the ribbon.

Introduction

Overview of typical rating / scoring model design and construction process – applies to both wholesale and retail

- Decision: what is the business purpose of the model?
- Data: sample design
- Model specification
  - Choice of variables and formats.
  - Choice of statistical techniques.
  - Qualitative, discretionary, or override factors.
  - Final rating estimates.
  - In-time / out-of-time sample testing

Introduction

Validation processes are appropriate at every stage

- Three stages of model construction above correspond directly to the “developmental evidence” validation processes discussed in earlier presentation:
  - Detailed statement of business purpose.
  - Sample design: selection of dataset that represents target population.
  - Selection of valid and appropriate modeling techniques: expert judgment, statistical methodology, or combination.

Data

KEAL BanCorp., NA

- Sample selected from Compustat
  - 4,861 firms; 72,915 company-years
- 475 defaults from Compustat, bank internal database, and external data sources (such as bankruptcy.com)

Data

Data cleaning and scrubbing

- Deletions from dataset (most important only)
  - Non-commercial / non-industrial firms (by SIC code).
  - Cases of multiple defaults in 3 year period (only one retained).
  - Cases where could not find CUSIP.
  - Cases of major fraud litigation.
  - Cases of firms that declared bankruptcy to avoid large lawsuit pay-outs.
  - Cases of default of parent and sub (only parent retained).

Data Issues

- Low defaults: numbers and rates*
- Missing data: can fill in sometimes
- Use of external data sources: mapping
- Internal data: sample design, selection of variables, bank information systems
- Combined cross-section / time-series

* Basel Committee on Banking Supervision, Newsletter No. 6 (September 2005), "Validation of low-default portfolios in the Basel II Framework."

Choice of Variables

- Starting point: variables used for this particular type of model in past by bank or others
- Typically financial ratios
  - Large number to choose from.
  - Often alternative definitions.
- Begin with univariate analysis
  - Correlations of individual variables with defaults.

Choice of Variables

LOT of trial and error

- Criteria for selection
  - Sets of variables with best discriminatory power.
  - Parsimony: minimize multicollinearity and avoid overfitting.
  - Minimize number of default observations with missing data.
  - Where there are multiple definitions of a ratio, choose simplest one.
  - Expert judgment by model builders and / or field staff is often necessary.

Choice of Variables

KEAL BanCorp.

- Over 50 ratios to choose from.
- Using processes and criteria outlined above, after extensive testing, arrived at final list:
  1. Liquidity (working capital / total assets)
  2. Leverage (total liabilities / total assets)
  3. ROE
  4. Interest coverage (net operating income + income tax + interest expense / interest expense)
  5. Total debt / total capital (including rentals and capitalized leases)
  6. Firm size (Ln(Assets))
- All testing, results, criteria, and final choices should be fully documented.

Model Specification

- Observation window: 12 months. Model based on relationship between independent variables (ratios and size) in year ending December 31 and outcome (default or non-default) during the following 12 months.
- Censoring of ratio outliers: pro and con.
- Segmentation by industry grouping
  vs. single national model.
- Format of financial ratios: transformed (e.g., log, "binned," or ranked) or untransformed.

Modeling Techniques

KEAL considered large number of techniques, including OLS, ordered probit, decision tree (CHAID), and logit (both standard and nested).

- Different techniques entail different dependent variables and in some cases would require different independent variables in the sample dataset.
  - Ordered probit and CHAID can directly estimate the risk-rating category or bucket for individual corporate exposures.
  - OLS can estimate the score (log odds) based on dichotomous (0,1) outcomes data; or the risk-rating category.
  - Logit can estimate the score (log odds) based on dichotomous (0,1) outcomes data.

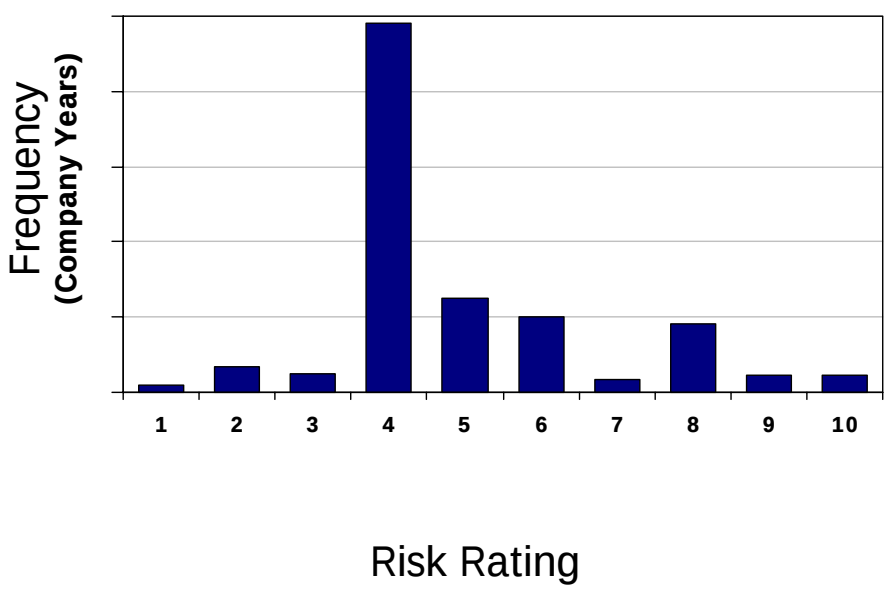
Choice of Modeling Technique

After initial testing, bank narrowed choices to two: nested logit, which can capture non-linear relationships, and standard logit (both with untransformed ratios).

- Results:
  - Both separated defaults from non-defaults effectively.
  - Based on obligor risk rating system with 10 grades of equal score width, standard logit produced more reasonable and appropriate distribution across ratings. (See Figure 1.)
  - Standard logit had slightly better CAP curve (see Figure 2) and Accuracy Ratio (86.7 vs. 81.2).
  - Although nested logit captured non-linear relationships, it was more difficult to interpret, and coefficients and outcomes can be statistically unstable.
  - Therefore, KEAL chose the standard logit as its final rating model. (See Figure 3.)

Risk Rating Distributions

Nested Logit



Standard Logit

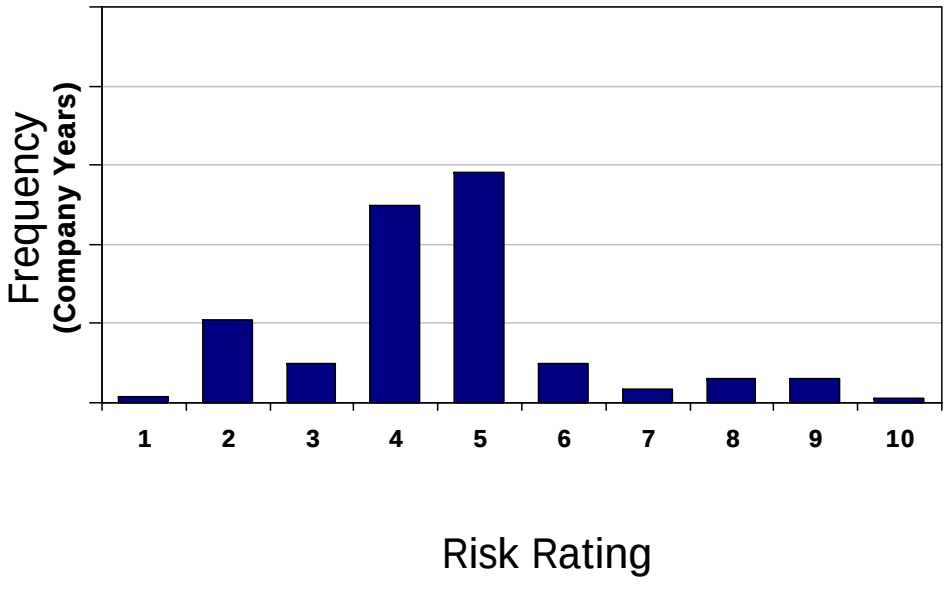


Figure 1

Results of Nested and Standard Logit Models

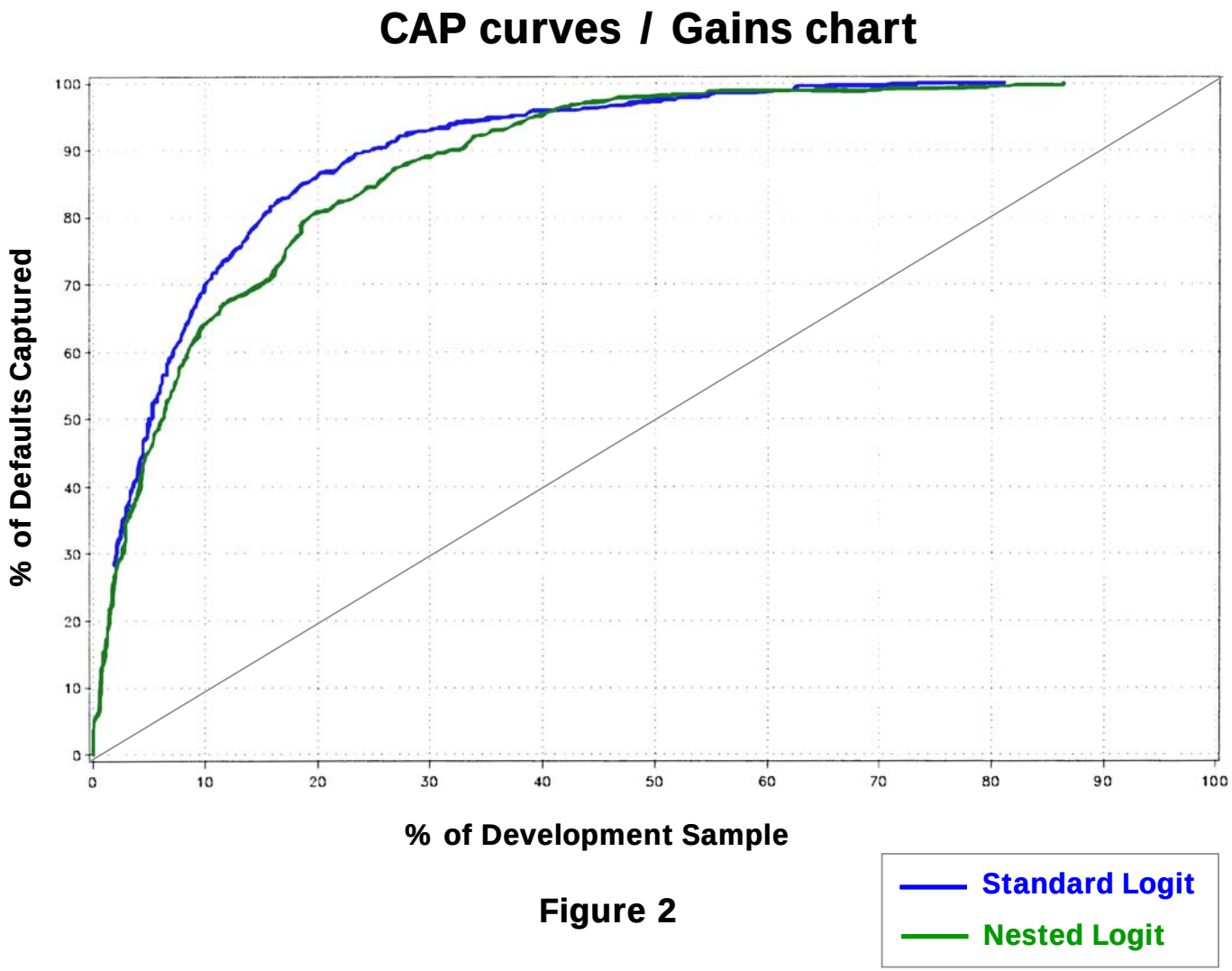


Figure 2

Final Risk-rating Model

KEAL Bancorp.

Variable	Coefficient	p-value Pr > Chi Sq
Intercept	- 4.501	<.0001
Liquidity	- 2.011	<.0001
Leverage	7.922	<.0001
ROE	- 0.093	<.0001
Interest Coverage	- 0.015	<.0001
Total debt / total capital	0.158	<.0001
Ln (assets)	- 0.106	<.0001

Figure 3

Qualitative Factors

Four general questions answered by line of business or risk managers, used to adjust, or supplement, results of scoring model.

- Each question can be answered Weak (-0.125 points); Neutral / Average (0); or Strong (+0.125).
- Point total (-0.5 to +0.5) added to score.

Qualitative Factors

Questions:

1. Regulation / supervision: Intensity of government supervision; prospects for added burden or deregulation.
2. Industry characteristics: Growth prospects (short- and long-term); vulnerability to natural disasters or cut-offs of supply (e.g., OPEC).
3. Managerial factors: Number of layers; encouragement of or opposition to innovation; succession planning.
4. Competition / concentration in industry, among suppliers and among customers.

- Loan officers and risk managers work with model developers. Based on their experience in the lending process, they play a significant role in choice of variables and qualitative questions.

Validation Issues: Modeling Techniques

- All techniques, model estimates, and results should be fully documented.
  - Bank provided CAP curves, Accuracy Ratios, and distributions by risk ratings for 2 “finalists,”
    - but no K-S statistics or divergence indices for the individual models.
  - Bank provided no testing or diagnostics at all for the “final” model including the scores as modified by the qualitative questions.

In-time / Out-of-time Sample Testing

Bank chose random sample that was not used in the development model.

- 1,739 firms; 26,085 company years; 170 defaults (all before data cleaning and scrubbing).
- Ran final model on this sample.
  - Reported Accuracy Ratio of 79.3 (vs. 86.7 for development sample).

In-time / Out-of-time Sample Testing

Validation issues:

- What does difference of 7.4 in AR mean? Bank has set no thresholds, no margins to trigger any particular processes (such as model review).
- Bank should report full results and diagnostics for out-of-time sample, to permit thorough cross-validation and analysis of indications of possible overidentification and/or misspecification.
  - Comparison of all individual coefficients (magnitude, sign, and significance).
  - Risk-rating distribution.
  - CAP curve.
  - K-S statistic and / or divergence indices.

One Last Step in Model Design and Building

Putting model into production

- Hand-off from model development / validation team to IT production.
- Hand-off from Developmental Evidence validation processes to Process Verification and Benchmarking.
- For both of those transitions:
  - Critical importance of documentation, transparency.
  - User training.

Conclusions

Validation is a central aspect of model development.

- Should be integral part of every stage.
- Should be planned from day one as part of design process.
- Not something you can put off thinking about until model is almost ready to roll.

- Despite differences in details and terminology, there are fundamental similarities between wholesale and retail in model design and validation.

References

Basle Committee on Banking Supervision, Newsletter No. 6 (September 2005), “Validation of low-default portfolios in the Basel II Framework.”