SOVEREIGN AND MUNICIPAL DEFAULT PROBABILITY RESEARCH

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May 2013
History of U.S. Municipal Ratings
Pre-1940

- 1918: Moody’s begins publishing annual Municipal and Government Manual. The manuals include bond ratings and are purchased mostly by investors.
- 1929: 55% of US munis are rated Aaa and another 23% are rated Aa.
- 1933: Peak of muni default wave. Most defaults caused by over-bonding, poor revenue source diversification, property tax delinquencies and bank closures/bank holidays
  - Over 4700 muni defaults during the 1930s.
  - 10-Year default rate for 1929 Aaa rated munis is 10%.
  - 10-Year default rate for 1929 Aa rated munis is 25%.
  - Overall, munis underperform corporates in each rating category.
- 1939: 1% of US munis are rated Aaa and 14% Aa.
This shortcoming of inadequate analysis is natural, indeed, in view of the size of the task. For instance, the 1937 industrial manual of Moody lists 5,032 companies on which statistical information has been gathered and prepared; 691 bond issues of these companies have been rated. The utility staff of the same agency covered 1,986 companies "fully" and added short paragraphs on a further 347 units; 1,547 public utility bonds were selected for rating. As to railways, 1,597 roads are listed with 1,668 issues rated. The municipal manual discussed 14,711 taxing bodies and rated 4,816 securities of 3,704 issuing units. One cannot escape being impressed by the volume of expensive work involved - and by the conclusion that a uniform pattern of rating, making all these different issues comparable with one another in terms of some nine grades, handled by a large staff of moderately paid analysts with necessarily divergent experiences, biases, and opinions, can only be applied if based on none but obviously visible and easily comparable features. The staggering cost of detailed study of some 23,000 issuing units, or even of the almost 9,000 rated issues, is prohibitive. Accordingly, the responsible agencies advise the customer not to rely upon the ratings alone but to use them together with the text of the manual and even to buy special investment advisory services which they are ready to supply. The candid observer cannot help wondering whether it would not be a still more responsible attitude to stop the publication of ratings altogether in the best interest of all concerned.

- Melchior Palyi, Journal of Business of the University of Chicago, January 1938
Mid 20th Century

- 1949: S&P starts issuing muni ratings. Small issuers given the option to pay for a rating.
- 1963: Moody’s and S&P rating levels remain near post-Depression lows despite two decades of minimal defaults.
- 1968: S&P migrates to the issuer-pays model for all munis. Moody’s follows shortly thereafter.
“…”

[N]o one, including some of the analysts involved, with whom we have spoken, with whom others that we know have spoken at very great length indeed, are quite sure what a rating is based upon. The criteria are foggy. The rating services maintain a sort of an aloofness and are not too willing to discuss with the representatives in municipal offices of cities what it is about the city that occasions the upward or downward move in a rating.

- Roy Goodman, Director of Finance, New York City, In Congressional Testimony, Dec. 5, 1967
Recent History

- **1999**: Fitch study finds that post-1979 default rates in most muni sectors were very low, suggesting that municipal ratings and corporate ratings are not comparable. Moody’s reports similar results in 2002.

- **2002**: Hedge fund manager Bill Ackman issues a research report on MBIA revealing that it is 139 times leveraged and thus not deserving of its AAA/Aaa rating.

- **2008**: California Treasurer Bill Lockyer reports that California paid $102 million for “unnecessary” municipal bond insurance; Moody’s Laura Levenstein claims that the dual muni/global ratings scale dates from 1920; Connecticut Attorney General Richard Blumenthal sues rating agencies over inconsistencies between muni and corporate rating scales.
All three credit rating agencies systematically and intentionally gave lower credit ratings to bonds issued by states, municipalities and other public entities as compared to corporate and other forms of debt with similar or even worse rates of default, Blumenthal alleges.

As a result of these deceptive and unfairly low ratings, Connecticut's cities, towns, school districts, and sewer and water districts have been forced to spend millions of taxpayer dollars to purchase bond insurance to improve their credit rating, or pay higher interest costs on their lower rated bonds.

"We are holding the credit rating agencies accountable for a secret Wall Street tax on Main Street -- millions of dollars illegally exacted from Connecticut taxpayers," Blumenthal said. "Connecticut's cities and school districts have been forced to spend millions of dollars, unconscionably and unnecessarily, on bond insurance premiums and higher interest rates as a result of deceptive and deflated credit ratings. Their debt was rated much lower than corporate debt despite their much lower risk of default and higher credit worthiness.

The Financial Crisis to Today

- Most monoline insurers go bankrupt or suffer multiple-notch downgrades (due to insuring toxic MBS and CDOs)
- Auction rate market freezes
- In April 2009, Moody’s places the entire muni sector – i.e., all issuers – on negative outlook
- In December 2010, Meredith Whitney panics the muni market by incorrectly forecasting 50-100 or more sizeable defaults in 2011
- Connecticut lawsuit is settled for $900k of credits for future ratings services and no admission of guilt
- Annual muni bond default rates remain low. Default rates on rated munis and General Obligations remain even lower
Takeaways

- Municipal bond ratings performed poorly during the Depression.
- Rating agencies (over)-reacted by severely grading municipalities for the next 70 years, creating the so-called dual ratings scale.
- Severe municipal ratings gave rise to the monoline bond insurance industry, which received billions of taxpayer dollars and then blew itself up by using proceeds to insure toxic structured finance assets.
- Problems occurred under both the issuer-pays and investor-pays models. Issues with municipal bond rating quality are only partially explained by incentives; the real problem has been insufficient rigor.
What the Market Needs

Municipal bond assessments that:

- Are based on thorough research of historic credit performance and issuer-specific financial conditions rather than conjectures and generalizations
- Rely primarily on quantitative approaches (given the large number of issuers together with the expense and subjectivity of analytical talent)
- Are transparent and thus clearly understood by participants on both the buy and sell sides

These comments apply to sovereign ratings as well.
Depression Era Default Research & Modeling
Municipal Credit Scoring

Goal:
- Use empirical methodology to calculate credit scores for California (and potentially other US cities)

Approach:
- Use a composite of financial statistics published in each city’s Comprehensive Annual Financial Report
- Fully transparent methodology
- Score should take the form of a default probability

Benefits
- Easy to keep current
- Can be applied to all issuers – even those that don’t purchase bond ratings
Why a Default Probability?

• Default probability scores would allow us to estimate “fair value” yields for municipal bonds

• Other components of fair value include:
  ➢ Recovery rate
  ➢ Risk premium
  ➢ Tax treatment adjustments

• Fair value (aka intrinsic value) calculations are common for corporate and structured bonds – we could improve transparency and liquidity by applying this technique to munis

• A widely accepted system that translates fiscal changes to updated default probabilities and fair bond yields would assist issuers in analyzing the debt service impact of their policy choices
Estimating Default Probabilities

• Different types of models have been developed for different asset classes.

• The most relevant asset class for our purpose is debt issued by private (i.e., unlisted) firms such as Moody’s Riskcalc.

• The dominant methodology for estimating private firm default probability involves the following:
  ➢ Gather data points for a large set of firms that have defaulted and for comparable firms that have not defaulted
  ➢ Use theory and statistical analysis to determine a subset of variables that distinguish between defaulting and non-defaulting firms
  ➢ Use statistical software to fit a model on the selected variables. Data for current issuers can then be entered into the model to calculate their default probabilities

• George Hempel applied a similar approach to municipal bonds in a 1973 study, but only had access to a small data sample.
Applying this Approach

• Problem: Lack of recent defaults.
  ➢ Income Securities Advisors’ database contains fewer than 40 general obligation bond defaults between 1980 and mid-2011.

• Solution: Follow the example of Reinhart & Rogoff (2009) by looking at older defaults.

Source: Kroll Bond Rating Municipal Bond Study (2011). Public domain data collected by and in possession of PSCS.
Will the Depression Muni Experience Repeat?

Unlikely: We have not seen a buildup of municipal bond debt relative to GDP similar to the one that preceded the Depression. Municipal issuance surged after WW I as investors demanded tax free bonds and governments needed to build roads to accommodate newly popular automobiles.

State and Municipal Bonds Outstanding as a Percentage of GDP

Source: Kroll Bond Rating Agency Municipal Default Study, 2011. Public domain data collected and in possession of PSCS.
Gathering Depression-era Default Data

• Sources
  ➢ Old Moody’s bond manuals
  ➢ Old Census reports
  ➢ Newspaper accounts
  ➢ Records at state archives

• Technologies
  ➢ Some resources on Google books
  ➢ Library material needs to be photographed with proper lighting and a good camera
  ➢ Photographs can be processed by Abbyy FineReader, which performs Optical Character Recognition and can convert inputs to PDFs or spreadsheets
  ➢ Older material is usually too difficult to process automatically so offshore data entry personnel were used
US Municipal Bond Defaults: 1920 to 1939

- Over 5000 defaults in all
- Defaults heavily concentrated in specific states, esp. Florida, the Carolinas, Arkansas, Louisiana, Texas, New Jersey, Michigan, Ohio and California
- No defaults reported in Maryland, Delaware, Connecticut, Vermont and Rhode Island

Yellow = Special Districts
Red = School districts
Green = Cities, States and Counties

Source: Public Sector Credit Solutions Default Database
Drivers of Depression-Era Defaults

• Poor control of municipal bond issuance in certain states such as Florida (which had outlawed state debt), Michigan, New Jersey and North Carolina.

• Many defaults stemmed from bank failures and bank holidays. When banks holding sinking funds and other municipal deposits were not open, issuers could not access cash needed to perform on their obligations.

• Prohibition had eliminated alcohol taxes as a revenue source; local income and sales taxes had yet to become common. Cities were thus heavily reliant on real estate taxes. When real estate values fell and property tax delinquencies spiked, many issuers became unable to perform.

• Many defaults occurred in drainage, irrigation and levee districts. Bonds funding these agricultural infrastructure projects were serviced by taxes paid by a small number of farmers or farming companies. A single delinquency could thus trigger a default.
Analysis and Modeling of Large City Defaults

• Strongest predictor was ratio of Interest to Total Revenue.
• Mean ratio for defaulting cities was 16.1% versus 11.0% for non-defaulters.
• High ratio non-default observations were concentrated in Virginia – which has a unique law requiring the State to cover municipal bond defaults. A dummy was added to address this state-specific attribute.
• Change in Annual Revenue was also significant.
• Population changes and cash balances were not significant.

![Box plot and table showing analysis of large city defaults](image)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>p</th>
</tr>
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<tbody>
<tr>
<td>Interest/Revenue</td>
<td>17.41951</td>
<td>1.99172</td>
<td>0.000</td>
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<tr>
<td>Virginia Dummy</td>
<td>-3.695301</td>
<td>1.471739</td>
<td>0.012</td>
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<tr>
<td>Δ Revenue</td>
<td>-1.964635</td>
<td>-1.964635</td>
<td>0.042</td>
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<tr>
<td>Constant</td>
<td>-4.13551</td>
<td>0.3037248</td>
<td>0.000</td>
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</tbody>
</table>

\[ dp = \exp(-4.14 + 17.42IR - 3.70VA - 1.96ΔR) / (1 + (-4.14 + 17.42IR - 3.70VA - 1.96ΔR)) \]
Some Other Observations

• Pensions and Other Post Employment Benefits (OPEB) are a threat to certain issuers, but we should consider the following:
  ➢ Underfunded pensions are nothing new
  ➢ Discussion around the issue is often distorted by political considerations. In particular, comparisons between a government’s annual budget (a flow) and its unfunded liabilities (a stock reported in present value terms) are not meaningful
  ➢ Future pension and OPEB expenditures should be estimated and compared to projected revenues

• Recoveries on municipal bond defaults have been quite high both during the Depression and more recently. New York City (1975) and Orange County (1994) both had full recoveries. Jefferson County, Stockton and San Bernardino creditors may not be as fortunate, however.
Public Sector Credit Framework
Two Quantitative Methodologies

PSCS is developing two methodologies for estimating government bond default probabilities.

- Simple logistic regression model for cities and other smaller issuers
- Multi-Year budget simulation tool for states, countries and other large issuers. Could also be applied to larger cities and counties. This open source tool is called the “Public Sector Credit Framework” - PSCF
PSCF Principles

Public Sector Credit Framework is:

- **Quantitative** – To decrease the likelihood that unconscious biases will affect the analysis and to take advantage of the computer’s ability to rapidly perform large numbers of calculations.

- **Transparent** – So that other analysts can examine and update assumptions.

- **Open Source** – In the hope that a community of developers will form to enhance the tool.

The open source release is only a framework. Users or vendors would have to build their own issuer-specific models.
PSCF Solution Overview

Quantitative methodology based on:
- Multi-Year Budget Projections for Each Public Sector Issuer
  - Can rely in part on estimates published by the government itself
- Monte Carlo Simulation of economic variables such as GDP growth, inflation and interest rates
  - Forecasts and historical data are available from a number of vendors including IHS Global Research
- Default point stated in terms of a fiscal ratio
  - Debt to GDP
  - Interest Expense to Revenue
  - Debt to Assessed Valuation
  - Others?
- Annual default probabilities calculated as the percentage of simulation trials resulting in ratios surpassing the default point; DPs can be mapped to ratings within the framework
Technology Overview

- User interface implemented as an Excel add-in
- User enters simulation data in two tabs of the spreadsheet and then runs the simulation from a control panel
- Excel inputs are converted to a C program, the program is compiled and then executed. Results are written to text file(s) and loaded into Excel tab(s)
- C program is compiled with the GNU C++ compiler and is thus compatible with Linux and other operating systems. GNU compiler is installed with the framework
- We also install the Boost C++ library which we use for random number generation
- C language and compiling are used in order to maximize speed enabling the user to run complex simulations and large numbers of trials
- We hope that programmers participating in the open source community will port the capabilities to other environments
Walkthrough Part 1: Model Sheet

First metric used to establish the default point

Additional metrics can be calculated and viewed in Projection Details
Part 2: Series Sheet / Random Numbers

- Create any number of random series.
- One random number generated per series per trial.
- Three random number distributions supported:
  - Uniform / Normal / Cauchy-Lorenz (allowing fat tails)
- User can impose maxima and minima on generated numbers
Inflation, GDP and interest rates can be modeled using any combination of constants, functions of random numbers and functions of other variables or prior year values.

Any C-compliant expression may be used.

Minima and maxima also supported.

Can use different formulae for different years.
Revenue and expenditure items can also use any valid C expression.

Items may be linked to macroeconomic variables such as inflation or GDP.

Annual surpluses or deficits can be computed from the revenue and expenditure series and then added to the previous year’s debt.
Walkthrough Part 5: Adjustments Sheet

- Legislative/executive decisions to reduce deficits (or spend large surpluses) can be simulated in the adjustments sheet.
- Revenue/Expenditure ratios can be bounded and changes to either revenues or expenditures can be distributed pro rata back to select budget lines.
- Would like to support more constraints in future releases.
Associate cumulative default probabilities with rating grades.

Any rating system can be used.

System returns a vector of annual ratings in recognition of the fact that bonds with different terms have different levels of risk.
Walkthrough Part 7: Results Sheet

<table>
<thead>
<tr>
<th>Year</th>
<th>Default Count</th>
<th>Default Probability</th>
<th>Cumulative Default Count</th>
<th>Cumulative Default Probability</th>
<th>Rating Equivalent</th>
<th>Minimum Interest Expense/Total Revenue</th>
<th>Maximum Interest Expense/Total Revenue</th>
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</thead>
<tbody>
<tr>
<td>2012</td>
<td>0</td>
<td>0.0000</td>
<td>0</td>
<td>0.0000</td>
<td>N/A</td>
<td>0.0961</td>
<td>0.0981</td>
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<td>2013</td>
<td>0</td>
<td>0.0000</td>
<td>0</td>
<td>0.0000</td>
<td>AAA</td>
<td>0.0718</td>
<td>0.1593</td>
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<tr>
<td>2014</td>
<td>0</td>
<td>0.0000</td>
<td>0</td>
<td>0.0000</td>
<td>AAA</td>
<td>0.0536</td>
<td>0.2029</td>
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<td>2015</td>
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<td>0.0000</td>
<td>0</td>
<td>0.0000</td>
<td>AAA</td>
<td>0.0444</td>
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<td>2016</td>
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<td>0.0000</td>
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<td>0.2523</td>
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<tr>
<td>2017</td>
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<td>0.0000</td>
<td>0</td>
<td>0.0000</td>
<td>AAA</td>
<td>0.0347</td>
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<td>2018</td>
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<td>0.0002</td>
<td>2</td>
<td>0.0002</td>
<td>AA</td>
<td>0.0288</td>
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<tr>
<td>2019</td>
<td>11</td>
<td>0.0011</td>
<td>11</td>
<td>0.0011</td>
<td>A+</td>
<td>0.0278</td>
<td>0.3888</td>
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<tr>
<td>2020</td>
<td>22</td>
<td>0.0022</td>
<td>23</td>
<td>0.0023</td>
<td>A</td>
<td>0.0155</td>
<td>0.4425</td>
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<tr>
<td>2021</td>
<td>45</td>
<td>0.0045</td>
<td>50</td>
<td>0.0051</td>
<td>A-</td>
<td>0.0119</td>
<td>0.4615</td>
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<td>2022</td>
<td>90</td>
<td>0.0090</td>
<td>95</td>
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<td>BBB</td>
<td>-0.0185</td>
<td>0.4501</td>
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<td>2023</td>
<td>131</td>
<td>0.0131</td>
<td>145</td>
<td>0.0145</td>
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<td>2024</td>
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<td>2025</td>
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<td>0.0266</td>
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<td>2026</td>
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<td>2028</td>
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<td>0.0643</td>
<td>BB+</td>
<td>-0.2171</td>
<td>0.7819</td>
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Walkthrough Part 8: Projection Sheet

- Optional projection tab shows trial-by-trial, year-by-year results for each variable you want to see.
- Default flag is set whenever the first metric specified in the models sheet surpasses the default threshold.
Selected Media Coverage

FT Alphaville – Monte Carlo Simulated Credit Risk -
http://ftalphaville.ft.com/2012/05/02/983041/monte-carlo-simulated-
sovereign-credit/

Canadian Broadcasting Company – Rating Agency Rebellion -
http://www.cbc.ca/player/News/Business/ID/2258963934/

Concord Coalition – Do Bond Markets Underestimate the True Riskiness of
markets-underestimate-true-riskiness-us-treasuries

Global Treasury News – An Alternative to Sovereign Credit Ratings: PSCF
http://www.gtnews.com/Articles/2013/An_Alternative_to_Sovereign_Credit_Ratings__PSCF.html (Gated)

Government Finance News, February 2013 (Hard Copy)
Applications of PSCF

Provincial Solvency and Federal Obligations, Macdonald-Laurier Institute.


Italy Model – Covered in MF (Milano) – 26 July 2013

Modeling Illinois Credit, Mercatus Center. Forthcoming.
US Fiscal Crisis Probability