OPEN SOURCE MODELS AS AN ALTERNATIVE TO RATINGS FOR REGULATION

Marc D. Joffe

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Approaches to Credit Assessment

- Judgmental
  - Traditional “5 C’s” Credit Analysis
- Published Algorithm
  - Altman’s Z-Score
- Proprietary Computer Model
  - FICO, Moody’s KMV, Kamakura, RapidRatings, Intex
- Model plus Judgment
  - Structured Bond Ratings at NRSROs
- Transparent/Open Source Model
  - Public Sector Credit Framework

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Models vs. Ratings

- KMV model picked up Enron well ahead of the downgrade; RapidRatings claims that its model called out MF Global well before its downgrade.
- Contemporary computer-driven corporate default probability models are built upon a dense academic literature going back to Altman (1968) and Merton (1973).
- Complex structured finance transactions only became feasible with the popularization of PC technology in the 1980s. The entire asset class is built upon computer modeling.
- Operating a computer-driven default probability, expected loss or ratings model without analyst discretion has two key advantages:
  - Scope for bias and manipulation is limited
  - Assessments can be updated as soon as new data is obtained
- I believe that 1930s capital adequacy regulations embedding agency ratings had the unintended impact of locking in an older form of credit analysis which may have otherwise been replaced by technology.

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Addressing Criticism of Credit Modeling

- Models use fewer criteria than rating agency methodologies
  - The more variables used to determine a rating; the more difficult it is to monitor that rating. And, as we know, rating agencies have been criticized for performing inadequate surveillance.
  - Academic literature dating back Occam's Razor has emphasized the benefits of simpler – or more *parsimonious* – models. Unless additional variables materially increase explanatory power, they are not worth adding .
- Many factors impacting credit – such as the competence and integrity of issuer management – cannot be readily quantified
  - If a factor cannot be easily measured, it is more likely that assessments will vary widely across analysts and that the measurement process will be impacted by bias.
  - If these factors are hard to measure, they'll be even harder to monitor; thus there is little assurance that ratings based on these factors will remain fresh.

Proprietary vs. Open Models

- Major credit model vendors keep substantial portions of their methodology confidential out of concern that competitors and clients will replicate their work and use it without payment.
- A similar concern existed in the realm of computer operating systems until Linux demonstrated that a completely open source system could generate sufficient revenue from implementation and support services
- For profit vendors may be able to monetize open credit models especially if such models enjoyed the widespread use that would come from regulatory approval
- Proprietary models cannot substitute for ratings in regulation. Vendors can change their models without advising users and could be incented to do so by interested parties

Open Source/Transparent Model Initiatives

- National University of Singapore Risk Management Institute (Credit Risk Initiative) - http://rmicri.org/home/ (See materials provided separately)
  - Credit Risk Initiative calculates default probabilities for 29,000 listed firms on a daily basis
  - Not open source but methodology is fully documented and thus completely transparent
  - CRI planning to add private firm model in the near future
- Open Source Investor Services - http://www.os-is.com/
  - Provides free online ABS valuation models
  - Declared intention to go open source, but has not published code yet
- Open Models Valuation Company - http://www.omvco.com/
  - Initially supported by Don Tapscott, co-author of *Macrowikinomics*
  - Declared intention to produce transparent structured finance models
- Wikirating – http://www.wikirating.org
  - Poll based sovereign ratings and transparent, balanced scorecard methodology
  - Intends to employ crowdsourcing approaches to all ratings classes
- Public Sector Credit Framework (PSCS / PF2) – http://www.pf2se.com
  - Published source code for government bond simulation tool in May
  - Applied methodology to Canadian provinces in October 2012 think tank study
  - Methodology explained in a September 2012 journal article
  - Won mandate from California State Treasurer's Office to Build Muni Default Model

Analogy to XBRL

- Like XBRL in its early years, open source credit modeling is a good idea struggling to gain mindshare
- XBRL became mainstream after it was endorsed by the SEC
- The SEC can have the same impact on open source credit modeling
- And what about the social benefit?
  - XBRL: Accelerates the transfer of comprehensive financial data from issuers to investors
  - Open Source Credit Models: Facilitate ongoing improvement of credit risk methodologies so that investors both big and small can more accurately estimate the default probability and/or expected loss of risky securities

- Oh, and, by the way…
  - The municipal bond market could really use its own XBRL!

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Policy Recommendation

- Open source or transparent credit model results as an alternative to credit ratings and fixed algorithms in regulations being rewritten per Dodd Frank
- Open source models would require approval by a non-profit standards panel authorized by the SEC (referred to as a self-regulatory body previously)
  - Good analogies here are XBRL International and the World Wide Web Consortium (W3C) – an NGO that establishes standards for internet communication including HTML and XML
  - Standards panel could be attached to a single university or be staffed by academics from multiple universities
  - The International Association of Credit Portfolio Managers (http://www.iacpm.org) has a modeling group that could serve this type of role
- Standards panel should maintain a comments page for each approved model, so that users and regulators can learn about potential defects in these tools

About Public Sector Credit Solutions

- Our goal is to research, create and popularize models for objectively rating sovereign and sub-sovereign government debt
- As a general matter, we believe that US municipal bonds have been and continue to be under-rated by incumbent rating agencies relative to other types of fixed income securities
- This can be remedied by computing default probabilities and/or expected losses for munis. These DPs can then be converted to ratings using industry standard rating/DP and rating/EL maps
- We are working on two projects at the moment:
  - PSCF: An open source multi-year budget simulation model best suited to states, provinces and sovereigns. PSCF was released in May 2012. We are also collecting historical sovereign fiscal and default data to better parameterize this tool.
  - A logit model for cities. This project is based on our research into Depression-era municipal bond defaults and is being conducted under a grant from the California Debt and Investment Advisory Commission (CDIAC) is accepted.

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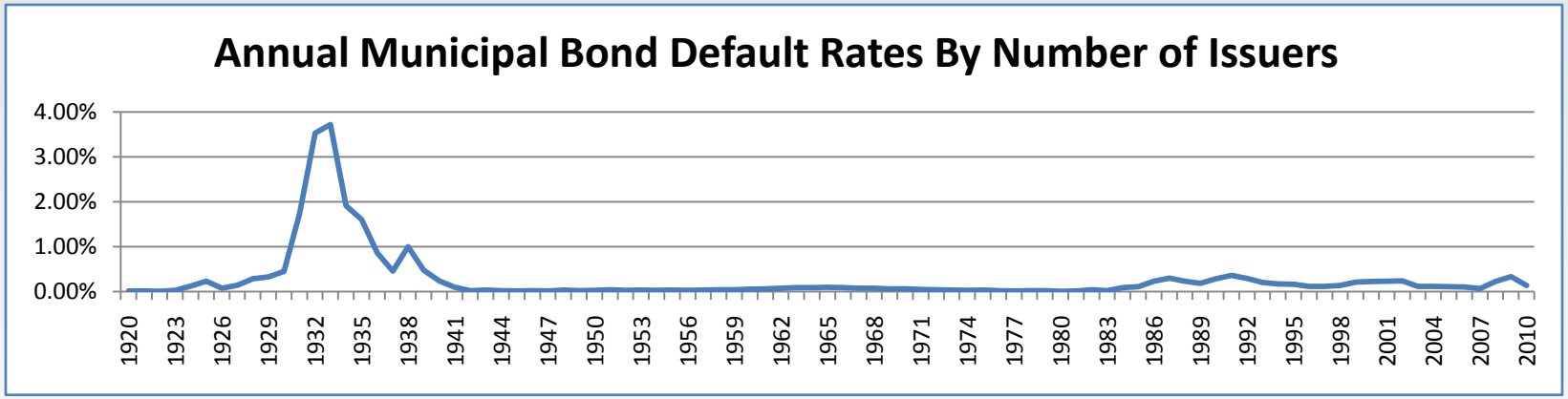
Estimating Muni Default Probabilities

- 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.
- The dominant methodology for estimating private firm default probability involves the following (see, Falkenstein, et. al., 2000):
  - 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 logit or probit model on the selected variables. Data for current issuers can then be entered into the model to calculate their default probabilities
- George Hempel (1973) applied this approach to municipal bonds, 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 and tax supported bond defaults between 1980 and mid-2011.



Source: Kroll Bond Rating Municipal Bond Study (2011)

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

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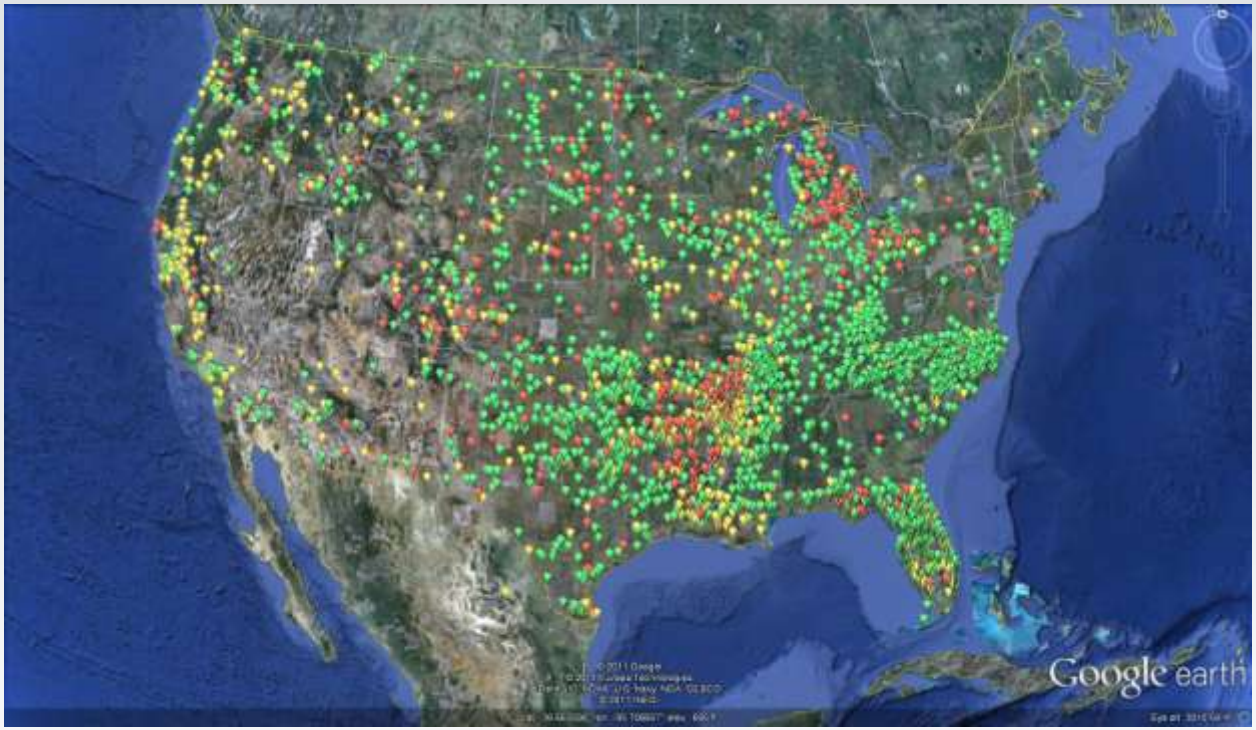
US Municipal Bond Defaults: 1920 to 1939



Yellow = Special Districts

Red = School districts

Green = Cities, States and Counties

Source: Public Sector Credit Solutions Default Database

- 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

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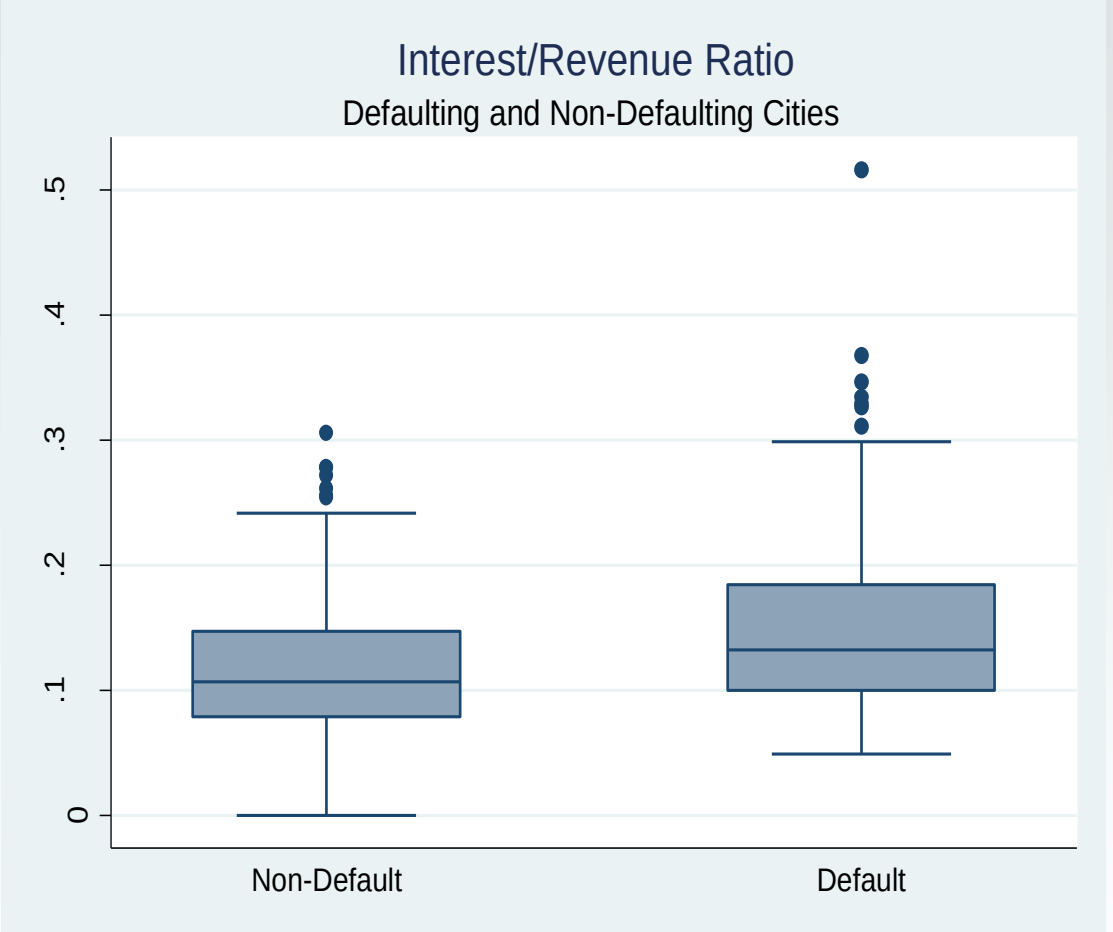
Drivers of Depression-Era Defaults

- 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.

Interest Expense to Revenue Ratio

- US Census reported annual fiscal data for major cities annually in the 1930s, so this ratio may be calculated.
- The box and whisker diagram at the right compares the ratio for defaulting and non-defaulting cities.
- High ratio non-default observations were concentrated in Virginia – which has a unique law requiring the State to cover municipal bond defaults.
- Still studying other outliers – some of the defaults with low ratios may be the result of bank failures or bank holidays.



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Next Steps

- Interest to revenue ratios could be one of a number of metrics used to create a municipal default probability score
- Other metrics in the model will need to address:
  - Vulnerability to revenue declines.
  - Proportion of “unmanageable” expenses (aside from interest) that will confront issuers in the near to intermediate term – pension costs being the most prominent example.
- Once the algorithm is developed scores should be regularly computed and made widely available
- While not a full replacement for fundamental credit analysis, municipal credit scoring promises to improve market access for smaller issuers and encouragement alignment of bond yields and underlying risks

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A Brief History of Municipal Bond 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.

Notable and Quotable…

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.
- 1965: Moody's downgrades New York City from A to Baa; S&P follows in 1966. Resulting controversy triggers Congressional hearings, a book-length study by the 20th Century Fund and other investigations.
- 1968: S&P migrates to the issuer-pays model for all munis. Moody's follows shortly thereafter.
- 1971: Ambac pioneers the monoline insurance industry. MBIA formed in 1974.

Notable and Quotable…

[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

Notable and Quotable…

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.

-***Connecticut Attorney General's Office Press Release, July 30, 2008***

The Financial Crisis to Today

- Most monoline insurers go bankrupt or suffer multiple-notch downgrades
- 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
- 2011 muni default rate (by count) was <0.4% as it has been every year for last 70 years. 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 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.

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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 or exclusively 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 sovereigns as well. The distinction between sovereigns and general obligation municipals is an artificial, rating agency driven convention. The same analytical approach can be applied to both sovereigns and GO munis. Different methods may be required for revenue bonds.

More on PSCF

Interest Expense to Revenue Ratio (States)

State	Interest Costs	Total Revenue	Interest / Revenue Ratio	Notes
Arkansas	7,764,000	26,157,000	29.68%	Default
South Carolina	4,725,000	25,089,000	18.83%	Forced Refunding
North Carolina	8,065,000	44,062,000	18.30%	
Tennessee	5,885,000	32,752,000	17.97%	
South Dakota	2,672,000	17,330,000	15.42%	
West Virginia	3,600,000	24,118,000	14.93%	
Alabama	4,402,000	31,360,000	14.04%	
North Dakota	2,143,000	15,381,000	13.93%	
Illinois	8,263,000	88,998,000	9.28%	
Oregon	2,763,000	29,767,000	9.28%	
Missouri	4,136,000	51,485,000	8.03%	
Mississippi	1,499,000	19,084,000	7.85%	
Louisiana	2,692,000	34,590,000	7.78%	Interest delay due to bank restrictions
New York	17,752,000	257,569,000	6.89%	
Minnesota	4,050,000	60,578,000	6.69%	
Rhode Island	845,000	13,141,000	6.43%	
New Mexico	574,000	10,795,000	5.32%	

All other states below 5%

Source: US Census, *Financial Statistics of State and Local Governments: 1932*

Two Suboptimal Approaches

1. Using issuer data to estimate bond ratings
   - Very common in the literature I reviewed (e.g., Loviscek, 1990)
   - Assumes that ratings can be used as a proxy for default probability
   - This is called into question by poor rating performance during the Depression and the recent recalibration
   - Extra credit question: What variable best predicts an issuer's 2012 bond rating?
   - Also see Nate Silver (2011) on serial correlation of sovereign ratings
2. Estimating default probabilities from bond yields
   - Assumes that the yields are the outcome of an efficient market – one that has incorporated all available information into the yield
   - Clearly not the case for illiquid markets, like those for most munis
   - If the muni market was efficient it wouldn't have cratered on Meredith Whitney's call and then provided excess returns when she proved to be wrong

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Toward a Term Structure of DPs

- One advantage of using market yields is that it is easier to estimate default probabilities over different time periods.
- Our open source tool, PSCF, provides another way to produce this "term structure of default probabilities" without relying on inefficient prices.
- As we move away from the present, key drivers of issuer performance like economic output, inflation, property values interest rates and policy choices become more uncertain.
- These uncertainties are addressed by running a multi-year budget simulation. After each trial and each year of the simulation, we can analyze projected fiscal results with our model. We can then sum up across all of our trials to compute annualized default probabilities.

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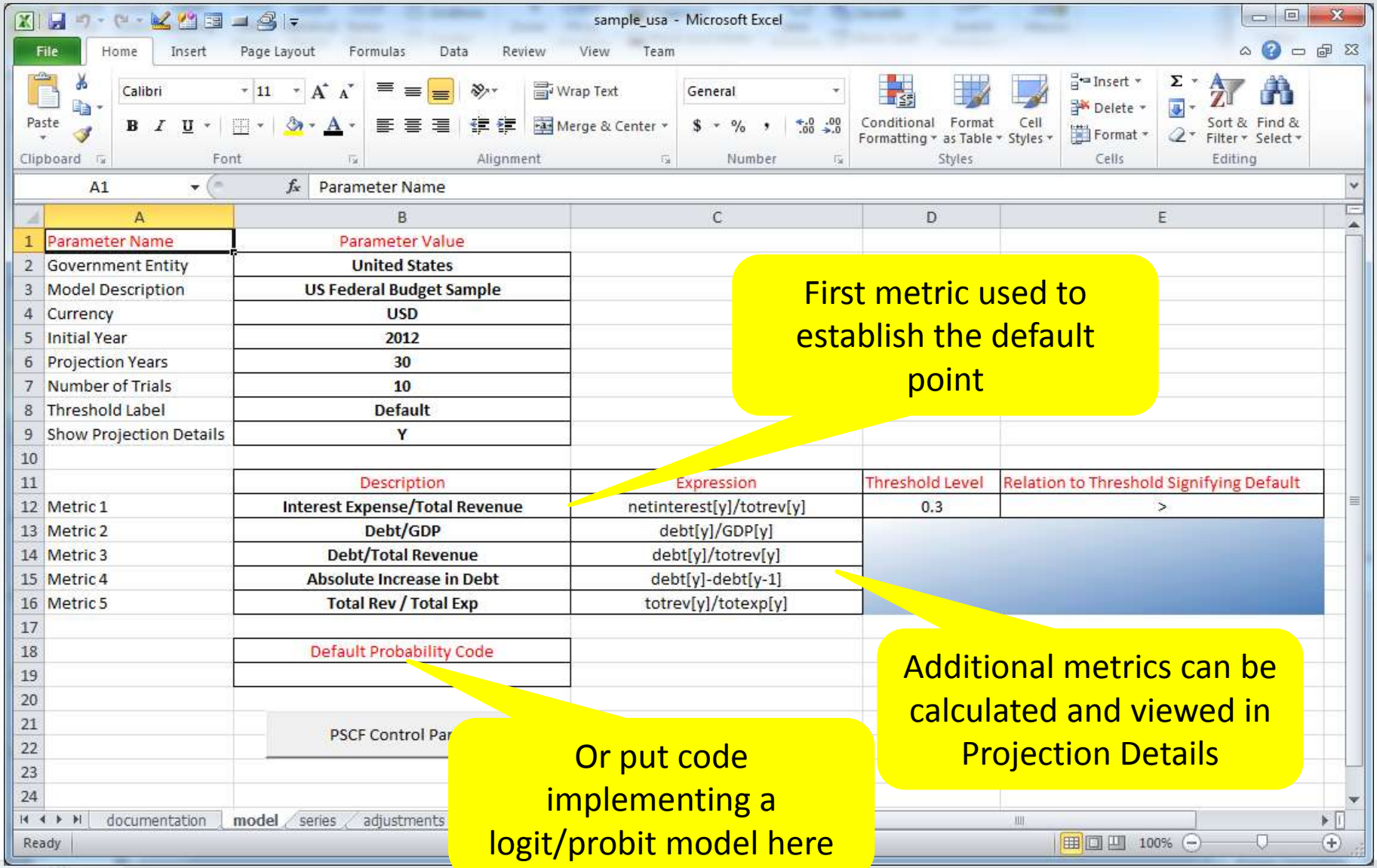
Walkthrough Part 1: Model Sheet



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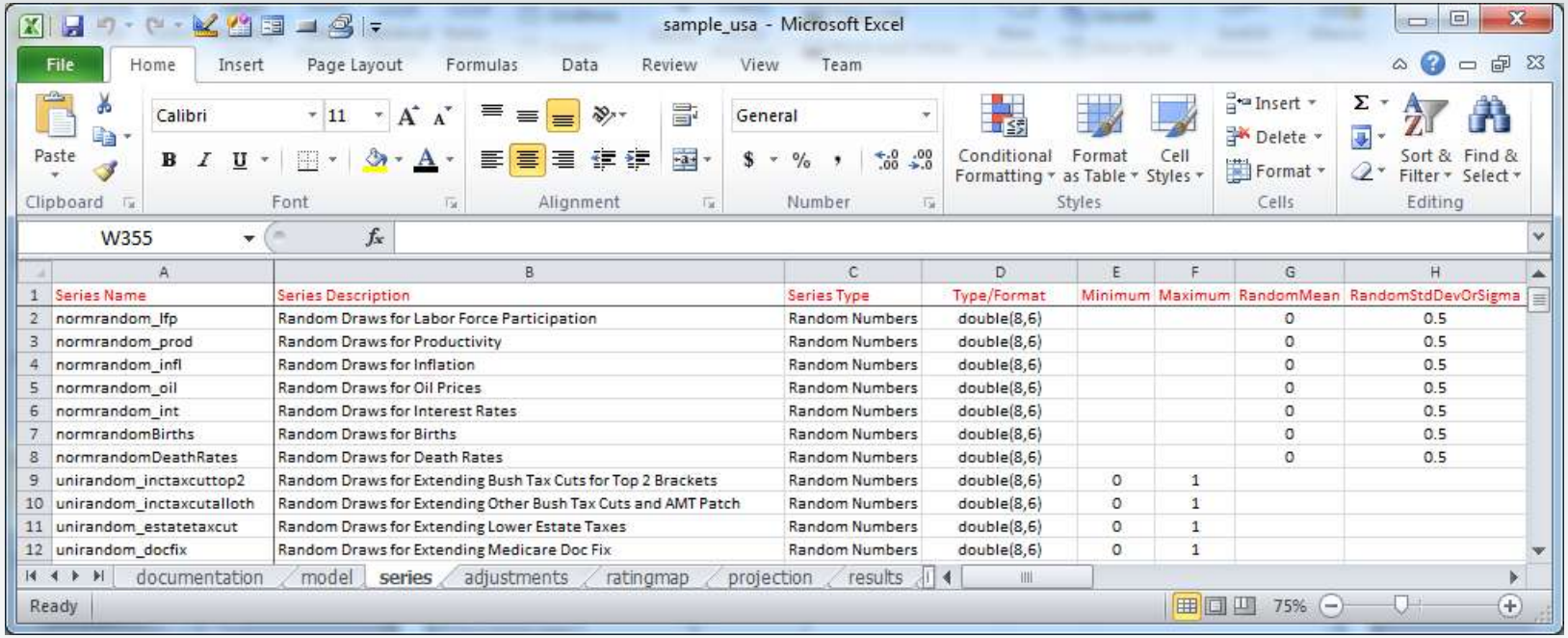
Part 2: Series Sheet / Random Numbers



	A	B	C	D	E	F	G	H
1	Series Name	Series Description	Series Type	Type/Format	Minimum	Maximum	RandomMean	RandomStdDevOrSigma
2	normrandom_lfp	Random Draws for Labor Force Participation	Random Numbers	double(8,6)			0	0.5
3	normrandom_prod	Random Draws for Productivity	Random Numbers	double(8,6)			0	0.5
4	normrandom_infl	Random Draws for Inflation	Random Numbers	double(8,6)			0	0.5
5	normrandom_oil	Random Draws for Oil Prices	Random Numbers	double(8,6)			0	0.5
6	normrandom_int	Random Draws for Interest Rates	Random Numbers	double(8,6)			0	0.5
7	normrandomBirths	Random Draws for Births	Random Numbers	double(8,6)			0	0.5
8	normrandomDeathRates	Random Draws for Death Rates	Random Numbers	double(8,6)			0	0.5
9	unirandom_inctaxcuttop2	Random Draws for Extending Bush Tax Cuts for Top 2 Brackets	Random Numbers	double(8,6)	0	1		
10	unirandom_inctaxcutalloth	Random Draws for Extending Other Bush Tax Cuts and AMT Patch	Random Numbers	double(8,6)	0	1		
11	unirandom_estatetaxcut	Random Draws for Extending Lower Estate Taxes	Random Numbers	double(8,6)	0	1		
12	unirandom_docfix	Random Draws for Extending Medicare Doc Fix	Random Numbers	double(8,6)	0	1		

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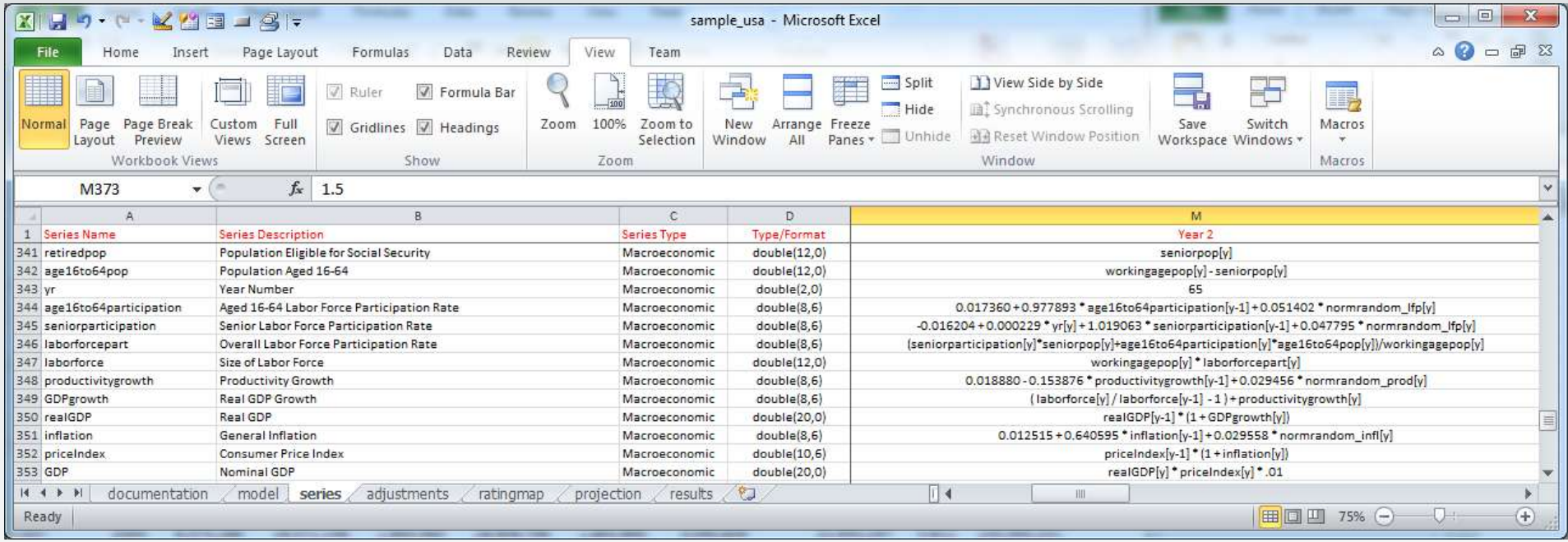
Part 3: Series Sheet / Macroeconomic Variables



	A	B	C	D	M
1	Series Name	Series Description	Series Type	Type/Format	Year 2
341	retiredpop	Population Eligible for Social Security	Macroeconomic	double(12,0)	seniorpop[y]
342	age16to64pop	Population Aged 16-64	Macroeconomic	double(12,0)	workingagepop[y] - seniorpop[y]
343	yr	Year Number	Macroeconomic	double(2,0)	65
344	age16to64participation	Aged 16-64 Labor Force Participation Rate	Macroeconomic	double(8,6)	0.017360 + 0.977893 * age16to64participation[y-1] + 0.051402 * normrandom_lfp[y]
345	seniorparticipation	Senior Labor Force Participation Rate	Macroeconomic	double(8,6)	-0.016204 + 0.000229 * yr[y] + 1.019063 * seniorparticipation[y-1] + 0.047795 * normrandom_lfp[y]
346	laborforcepart	Overall Labor Force Participation Rate	Macroeconomic	double(8,6)	(seniorparticipation[y]*seniorpop[y]+age16to64participation[y]*age16to64pop[y])/workingagepop[y]
347	laborforce	Size of Labor Force	Macroeconomic	double(12,0)	workingagepop[y] * laborforcepart[y]
348	productivitygrowth	Productivity Growth	Macroeconomic	double(8,6)	0.018880 - 0.153876 * productivitygrowth[y-1] + 0.029456 * normrandom_prod[y]
349	GDPgrowth	Real GDP Growth	Macroeconomic	double(8,6)	(laborforce[y] / laborforce[y-1] - 1) + productivitygrowth[y]
350	realGDP	Real GDP	Macroeconomic	double(20,0)	realGDP[y-1] * (1 + GDPgrowth[y])
351	inflation	General Inflation	Macroeconomic	double(8,6)	0.012515 + 0.640595 * inflation[y-1] + 0.029558 * normrandom_infl[y]
352	priceIndex	Consumer Price Index	Macroeconomic	double(10,6)	priceIndex[y-1] * (1 + inflation[y])
353	GDP	Nominal GDP	Macroeconomic	double(20,0)	realGDP[y] * priceIndex[y] * .01

- 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

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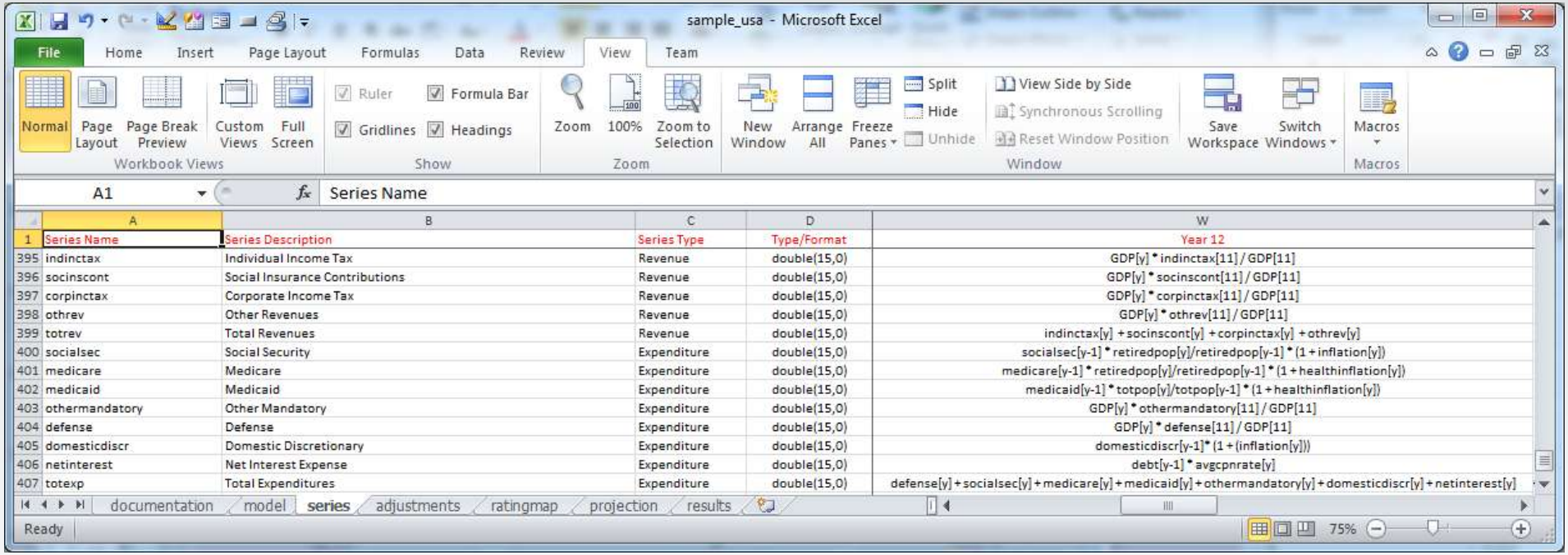
Part 4: Series Sheet / Revenues & Expenditures



	A	B	C	D	W
1	Series Name	Series Description	Series Type	Type/Format	Year 12
395	indinctax	Individual Income Tax	Revenue	double(15,0)	GDP[y] * indinctax[11] / GDP[11]
396	socinscont	Social Insurance Contributions	Revenue	double(15,0)	GDP[y] * socinscont[11] / GDP[11]
397	corpinctax	Corporate Income Tax	Revenue	double(15,0)	GDP[y] * corpinctax[11] / GDP[11]
398	othrev	Other Revenues	Revenue	double(15,0)	GDP[y] * othrev[11] / GDP[11]
399	totrev	Total Revenues	Revenue	double(15,0)	indinctax[y] + socinscont[y] + corpinctax[y] + othrev[y]
400	socialsec	Social Security	Expenditure	double(15,0)	socialsec[y-1] * retiredpop[y]/retiredpop[y-1] * (1 + inflation[y])
401	medicare	Medicare	Expenditure	double(15,0)	medicare[y-1] * retiredpop[y]/retiredpop[y-1] * (1 + healthinflation[y])
402	medicaid	Medicaid	Expenditure	double(15,0)	medicaid[y-1] * totpop[y]/totpop[y-1] * (1 + healthinflation[y])
403	othermandatory	Other Mandatory	Expenditure	double(15,0)	GDP[y] * othermandatory[11] / GDP[11]
404	defense	Defense	Expenditure	double(15,0)	GDP[y] * defense[11] / GDP[11]
405	domesticdiscr	Domestic Discretionary	Expenditure	double(15,0)	domesticdiscr[y-1]* (1 + (inflation[y]))
406	netinterest	Net Interest Expense	Expenditure	double(15,0)	debt[y-1] * avgcpnrate[y]
407	totexp	Total Expenditures	Expenditure	double(15,0)	defense[y] + socialsec[y] + medicare[y] + medicaid[y] + othermandatory[y] + domesticdiscr[y] + netinterest[y]

- Revenue and expenditure items can also use any valid C expression
- Items may be linked to macroeconomic variables such as inflation, home prices or economic output (GDP/GSP, personal income).
- Annual surpluses or deficits can be computed from the revenue and expenditure series and then added to the previous year's debt.

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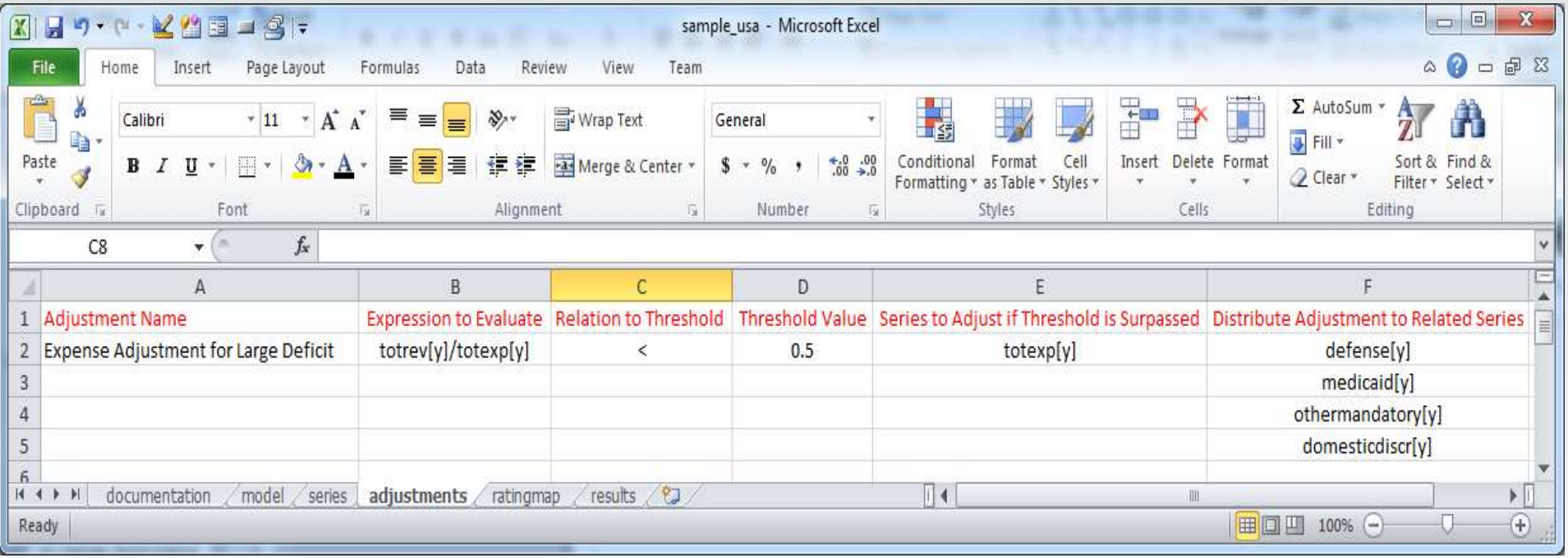
Part 5: Adjustments Sheet



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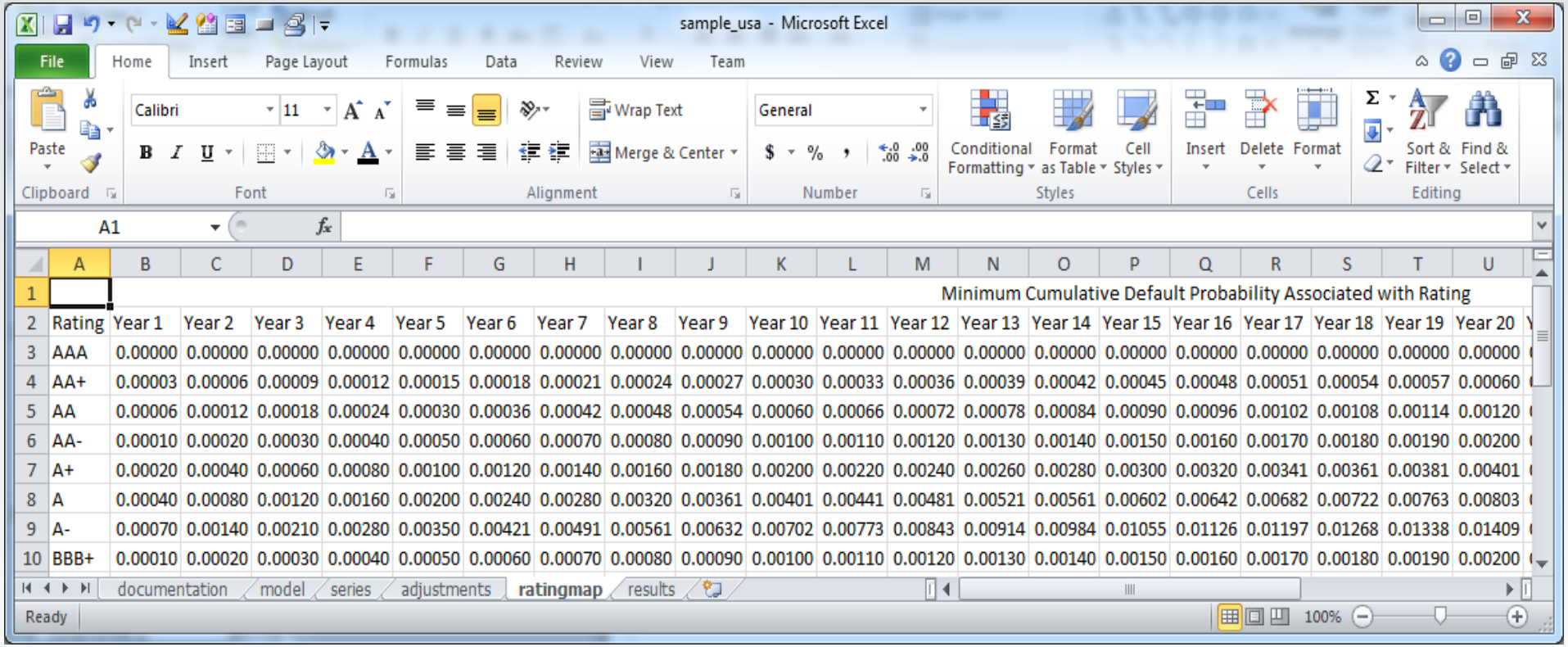
Part 6: Ratingmap Sheet



Rating	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
AAA	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
AA+	0.00003	0.00006	0.00009	0.00012	0.00015	0.00018	0.00021	0.00024	0.00027	0.00030	0.00033	0.00036	0.00039	0.00042	0.00045	0.00048	0.00051	0.00054	0.00057	0.00060
AA	0.00006	0.00012	0.00018	0.00024	0.00030	0.00036	0.00042	0.00048	0.00054	0.00060	0.00066	0.00072	0.00078	0.00084	0.00090	0.00096	0.00102	0.00108	0.00114	0.00120
AA-	0.00010	0.00020	0.00030	0.00040	0.00050	0.00060	0.00070	0.00080	0.00090	0.00100	0.00110	0.00120	0.00130	0.00140	0.00150	0.00160	0.00170	0.00180	0.00190	0.00200
A+	0.00020	0.00040	0.00060	0.00080	0.00100	0.00120	0.00140	0.00160	0.00180	0.00200	0.00220	0.00240	0.00260	0.00280	0.00300	0.00320	0.00341	0.00361	0.00381	0.00401
A	0.00040	0.00080	0.00120	0.00160	0.00200	0.00240	0.00280	0.00320	0.00361	0.00401	0.00441	0.00481	0.00521	0.00561	0.00602	0.00642	0.00682	0.00722	0.00763	0.00803
A-	0.00070	0.00140	0.00210	0.00280	0.00350	0.00421	0.00491	0.00561	0.00632	0.00702	0.00773	0.00843	0.00914	0.00984	0.01055	0.01126	0.01197	0.01268	0.01338	0.01409
BBB+	0.00010	0.00020	0.00030	0.00040	0.00050	0.00060	0.00070	0.00080	0.00090	0.00100	0.00110	0.00120	0.00130	0.00140	0.00150	0.00160	0.00170	0.00180	0.00190	0.00200

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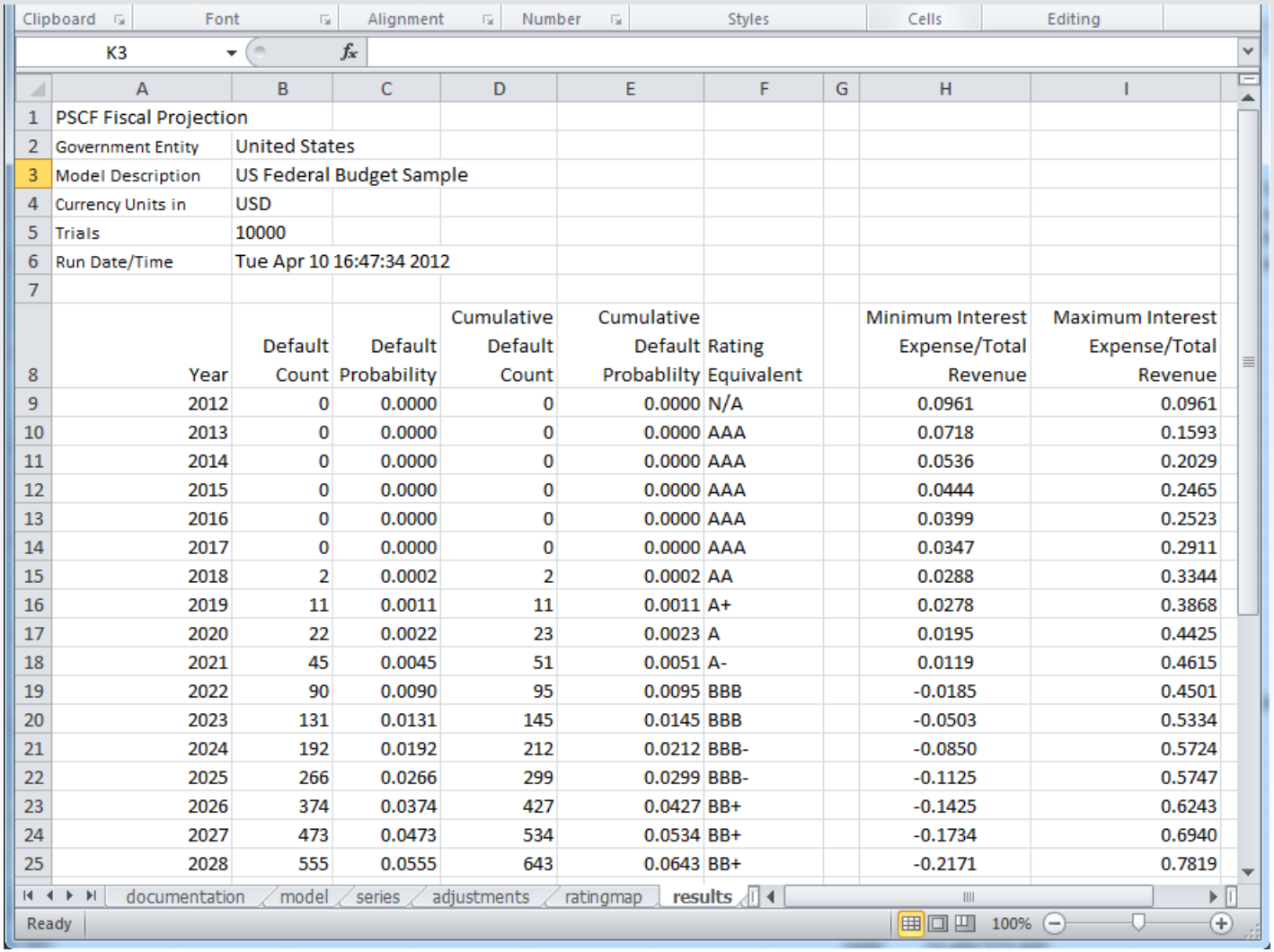
Part 7: Results Sheet



	A	B	C	D	E	F	G	H	I
1	PSCF Fiscal Projection								
2	Government Entity	United States							
3	Model Description	US Federal Budget Sample							
4	Currency Units in	USD							
5	Trials	10000							
6	Run Date/Time	Tue Apr 10 16:47:34 2012							
7									
8	Year	Default Count	Default Probability	Cumulative Default Count	Cumulative Default Probablilty	Rating Equivalent		Minimum Interest Expense/Total Revenue	Maximum Interest Expense/Total Revenue
9	2012	0	0.0000	0	0.0000	N/A		0.0961	0.0961
10	2013	0	0.0000	0	0.0000	AAA		0.0718	0.1593
11	2014	0	0.0000	0	0.0000	AAA		0.0536	0.2029
12	2015	0	0.0000	0	0.0000	AAA		0.0444	0.2465
13	2016	0	0.0000	0	0.0000	AAA		0.0399	0.2523
14	2017	0	0.0000	0	0.0000	AAA		0.0347	0.2911
15	2018	2	0.0002	2	0.0002	AA		0.0288	0.3344
16	2019	11	0.0011	11	0.0011	A+		0.0278	0.3868
17	2020	22	0.0022	23	0.0023	A		0.0195	0.4425
18	2021	45	0.0045	51	0.0051	A-		0.0119	0.4615
19	2022	90	0.0090	95	0.0095	BBB		-0.0185	0.4501
20	2023	131	0.0131	145	0.0145	BBB		-0.0503	0.5334
21	2024	192	0.0192	212	0.0212	BBB-		-0.0850	0.5724
22	2025	266	0.0266	299	0.0299	BBB-		-0.1125	0.5747
23	2026	374	0.0374	427	0.0427	BB+		-0.1425	0.6243
24	2027	473	0.0473	534	0.0534	BB+		-0.1734	0.6940
25	2028	555	0.0555	643	0.0643	BB+		-0.2171	0.7819

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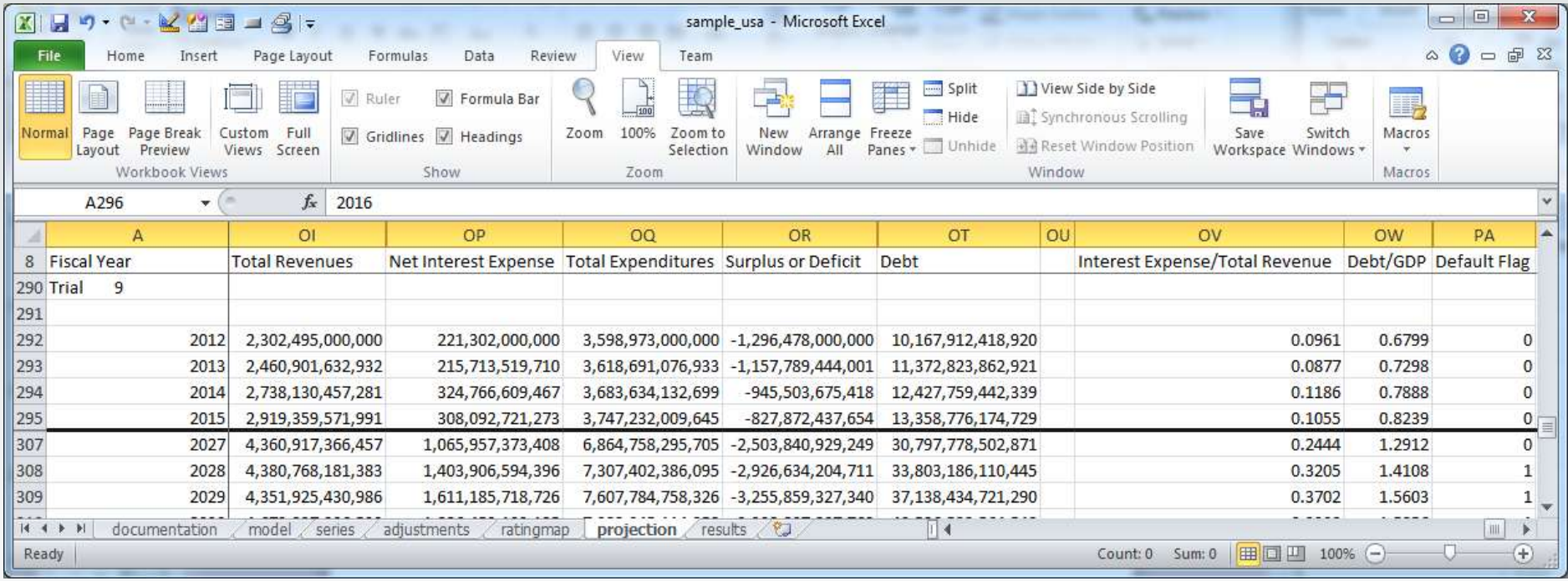
Part 8: Projection Sheet



	A	OI	OP	OQ	OR	OT	OU	OV	OW	PA
8	Fiscal Year	Total Revenues	Net Interest Expense	Total Expenditures	Surplus or Deficit	Debt		Interest Expense/Total Revenue	Debt/GDP	Default Flag
290	Trial 9									
291										
292	2012	2,302,495,000,000	221,302,000,000	3,598,973,000,000	-1,296,478,000,000	10,167,912,418,920		0.0961	0.6799	0
293	2013	2,460,901,632,932	215,713,519,710	3,618,691,076,933	-1,157,789,444,001	11,372,823,862,921		0.0877	0.7298	0
294	2014	2,738,130,457,281	324,766,609,467	3,683,634,132,699	-945,503,675,418	12,427,759,442,339		0.1186	0.7888	0
295	2015	2,919,359,571,991	308,092,721,273	3,747,232,009,645	-827,872,437,654	13,358,776,174,729		0.1055	0.8239	0
307	2027	4,360,917,366,457	1,065,957,373,408	6,864,758,295,705	-2,503,840,929,249	30,797,778,502,871		0.2444	1.2912	0
308	2028	4,380,768,181,383	1,403,906,594,396	7,307,402,386,095	-2,926,634,204,711	33,803,186,110,445		0.3205	1.4108	1
309	2029	4,351,925,430,986	1,611,185,718,726	7,607,784,758,326	-3,255,859,327,340	37,138,434,721,290		0.3702	1.5603	1

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Technology

- 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

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For More Information…

Credit Rating Agency Models and Open Source

http://expectedloss.blogspot.com/2012/04/credit-rating-agency-models-and-open.html

Multiple Rating Scales: When A Isn't A

http://expectedloss.blogspot.com/2012/04/multiple-rating-scales-when-isnt.html

Open Source Model Adds Transparency to Municipal Credit Rating

http://www.shareable.net/blog/open-source-platform-adds-transparency-to-municipal-credit-rating

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References

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Hempel, George H. (May 1973). Quantitative Borrower Characteristics Associated with Defaults on Municipal General Obligations. *The Journal of Finance, 28*(2), 523-530.

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