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Rating Government Bonds: Can We Raise Our Grade?

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LINK TO ABSTRACT

In John Moody's inaugural analysis of *Government and Municipal Securities*, published in 1918, the Aaa rating was described as follows: "Bond obligations, whether of countries or municipalities, which are given this rating, are to be regarded as of a high class type of investment and should be considered as entirely secure both as to principal and interest" (10). Since their inception, ratings have been intended to convey risk information to investors. More specifically, ratings are supposed to indicate the probability of default.

In the 94 years since Moody's first assessed government bonds, social science research methods have evolved substantially—far more than have the methods rating agencies use to analyze public sector debt. If a contemporary economist was charged with the task of estimating default probabilities for government bonds, he or she might address the problem by creating a logit or probit regression model fitted against the characteristics of defaulting and non-defaulting governments historically. Unfortunately, major credit rating agencies do not apply this approach to assessing sovereign and municipal bonds, nor do they use a number of other analytical techniques employed in the academic literature.

Academic and commercial models using binary dependent variable methods are well established for corporate credit risk analysis. Other quantitative techniques, including collateral simulations and cashflow waterfall analysis, have been applied to structured assets. FICO and others have used empirical analysis of consumer behavior to assign credit scores to most American adults. Of the various classes of debt, the category that has received the least attention from modelers is the one with most systemic importance: government bonds.

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As a Senior Director at Moody's Analytics until 2011, I learned the benefits of applying quantitative modeling techniques to credit. Moody's Analytics is one of a number of providers that have created successful, model-based alternatives to corporate credit ratings. Unfortunately, commercial vendors have been slow to apply advanced modeling techniques to sovereign and municipal bonds. Barriers include difficulties in acquiring standardized government financial data and a dearth of academic literature upon which models may be built. Software developers may also be concerned about the controversy surrounding government credit assessments, especially given the criticism that Standard & Poor's faced for its 2011 U.S. downgrade.

Given the systemic importance of government solvency, I believe much more needs to be done. Without accurate default probabilities, markets lack guidance needed to set interest rates in accord with underlying risk. Policymakers and the public receive confusing signals about the danger—or lack of danger—arising from their governments' debt burdens.

This paper will examine current rating agency processes, review academic literature on government credit risk, and discuss a research agenda addressing the need to multiply our measures of the risk of government bonds. This research agenda involves collecting historical default data and creating simulation-based government default probability models—work that my group, Public Sector Credit Solutions, has already started.

Rating agency processes

Rating agencies publish documents that explain the factors considered when assigning ratings to a specific class of instruments. Separate documents may be published for sovereign, state, and municipal bond issuers.

I recently reviewed rating methodology documents for U.S. local government issuers published by Moody's (2009), Standard & Poor's (2012a), Fitch (2012b), and Kroll Bond Rating Agency (2012). In aggregate, I found 170 unique factors considered by the four agencies when evaluating municipal credit. Many of these factors, such as "Predictability," are difficult to quantify in a formal analysis, while others would be expected to exhibit a high degree of multicollinearity, such as "Per Capita Income" and "Median Household Income."

Since municipal bond defaults are relatively rare, an approach relying on a much shorter list of variables should be both possible and desirable. The philosophy of science contains a substantial literature advocating simpler—or more parsimonious—models (see Forster and Sober 2004 for a detailed discussion of these issues).

Routine use of a methodology that relies on a large set of independent variables poses implementation challenges. To monitor their ratings effectively, agencies need to be able to collect and analyze updated data as they become available. In the absence of a multiple regression model, changes to independent variables have to be evaluated by analysts to determine whether they should trigger a rating upgrade or downgrade. Available evidence suggests that rating agencies do not effectively execute this monitoring role.

Rating agencies received substantial criticism for their monitoring of residential mortgage-backed securities (RMBS) and collateralized debt obligations (CDO) prior to the financial crisis of 2007 and 2008. The U. S. Senate Permanent Subcommittee on Investigations (2011, 307) found that:

> Resource shortages…impacted the ability of the credit rating agencies to conduct surveillance on outstanding rated RMBS and CDO securities to evaluate their credit risk. The credit rating agencies [CRAs] were contractually obligated to monitor the accuracy of the ratings they issued over the life of the rated transactions. CRA surveillance analysts were supposed to evaluate each rating on an ongoing basis to determine whether the rating should be affirmed, upgraded, or downgraded. To support this analysis, both companies [Moody's and Standard & Poor's] collected substantial annual surveillance fees from the issuers of the financial instruments they rated, and set up surveillance groups to review the ratings. In the case of RMBS and CDO securities, the Subcommittee investigation found evidence that these surveillance groups may have lacked the resources to properly monitor the thousands of rated products.
>
> At Moody's, for example, a 2007 email message disclosed that about 26 surveillance analysts were responsible for tracking over 13,000 rated CDO securities.

These findings relate to structured securities rather than government bonds, so perhaps they are not relevant. On the other hand, it is reasonable to think that if rating agencies under-invested in surveillance for their most profitable asset class—structured finance (Cornaggia, Cornaggia, and Hund 2012)—they have made similar or more egregious under-investments in the surveillance of other asset classes.[2]

2. The *New York Times* reported that, recently, "The sovereign debt team at Moody's [had] about a dozen people" (Creswell and Bowley 2011). The firm rates about 100 sovereigns.

Evidence that ratings do not do a great job of incorporating new information derives from transition matrices published by the firms. Under SEC rules, Nationally Recognized Statistical Rating Organizations (NRSROs) are required to include rating transition matrices as part of their annual regulatory filings. These matrices show the distribution of rating changes over a given period. In my own review of the transition matrices published by Moody's (2012, 25), Standard & Poor's (2012b, table 58), and Fitch (2012a, 10) I found that about 90 percent of municipal bond ratings remain unchanged within a given year.[3] For example, the Standard & Poor's transition matrix (for non-housing municipal issuers) showed that 89.11 percent of AA rated issuers remained AA the following year, while 0.18 percent were upgraded to AAA, 1.62 percent were upgraded to AA+ and a total of 9.09 percent were downgraded to various rating categories ranging from AA− down to BB+.

More interesting are the patterns of the ratings changes. When they occur, upgrades and downgrades are serially correlated, as noted by Nate Silver (2011). If ratings changes were the result of an unbiased process, it would not be possible to predict the future rating trend from the most recent rating change. Silver quotes a Standard & Poor's (2011) report showing that sovereign downgrades were followed by further downgrades in 52 percent of cases and upgrades in only 9 percent of cases over the next two years (there were no changes in the remaining 39 percent of cases during that interval). Upgrades were followed by further upgrades 37 percent of the time and downgrades only 6 percent of the time.

The infrequency and serial correlation of rating changes may be the result of the committee process employed by the firms. Rating changes must be proposed by an analyst, debated, and voted upon at a formal meeting. Rating agency rules clearly state that commercial considerations cannot enter into committee deliberations. The proceedings are confidential, however, and it is impossible for outsiders to determine how participants make their decisions. The serial correlation of rating changes makes us wonder about how political power influences or interacts with the commercial services in question.

Academic research

Limitations on the rating agency processes suggest that an opportunity exists to provide alternatives that predict better. In the matter of corporate bond ratings,

3. Ratings in the transition matrix are underlying ratings that do not reflect the benefits of municipal bond insurance. Prior to the financial crisis, many municipal bonds were rated AAA/Aaa because they were wrapped by policies issued by AAA/Aaa insurers, but credit rating agencies also reported underlying, unenhanced ratings.

a seminal journal article by Robert Merton (1974) eventually launched an industry dedicated to estimating public firm default probabilities based on the market value of their assets as measured by market capitalization. Since the independent variable changes frequently, default probabilities can be updated daily or even in real time. Bankruptcy risk modeling using financial statement data traces its origins to Edward Altman's (1968) Z-Score, and other early work, and has also been commercialized. Both Moody's and Standard & Poor's either acquired firms that commercialized these methodologies or developed them internally—offering evidence that the incumbent rating agencies recognize the validity and power of these quantitative approaches to corporate default probability assessment.

Most academic efforts to estimate government default probabilities have relied on market pricing. A number of researchers have attempted to derive default probabilities from bond yields or credit default swap (CDS) spreads (Remolona, Scatigna, and Wu 2007; Wang, Wu, and Zhang 2008; Longstaff, Pan, Pedersen, and Singleton 2011). In theory, bond yields should be a function of their issuer's credit risk. More specifically, yields should compensate investors for expected loss arising from a potential default. In the literature, expected loss is defined as the product of default probability and loss given default (LGD). LGD is simply the complement of a bond's rate of recovery, and is also called loss severity.

Theoretical bond yields contain a number of components aside from expected loss. Deepak Agrawal, Navneet Arora, and Jeff Bohn (2004) propose an equation for corporate bond yields that includes the risk-free rate of interest, the level of investor aversion to risk, the bond's maturity date, issuer size (as a proxy for liquidity), and the correlation of the bond's default risk with that of other instruments. Yields may also be affected by call provisions that give issuers the option to redeem their bonds prior to maturity.

With respect to U.S. municipal bonds, a further complexity arises as a result of their tax status. As interest on most municipal bonds is exempt from federal, state, and local income taxation, their yields are not directly comparable to those on taxable securities. Some adjustment to the municipal bond yield must be made in order to make it "taxable equivalent." One approach is to convert the tax-free yield to a taxable yield based on the highest prevailing marginal tax rate, on the assumption that municipal investors are predominantly high-income individuals. Given the complexities of the tax code, the heterogeneity of individual investors, and the participation of institutional investors (with different tax considerations), however, the use of the top marginal rate is but a coarse stand-in. John Chalmers (1998) finds that interest rate differentials between long term US Treasuries and federally insured municipals (which are assumed to have no default risk) are not consistent with the tax benefits available to individuals in the top tax bracket.

In corporate credit markets, analysts often derive default probabilities from CDS spreads rather than bond yields. Credit default swaps are insurance contracts that protect the holder against the impact of a default. If the issuer defaults, the CDS seller (or insurer) pays the buyer of the protection the face value of the bond and takes the bond in exchange. Deriving default probabilities from CDS spreads is easier than using bond yields because bonds have more structural complexities, such as call provisions. The applicability of CDS-implied default probabilities to the municipal market is greatly limited by the fact that CDSs trade against a very small number of municipal issuers.

While most large sovereigns are referenced by CDSs, liquidity in these issues is limited. Kamakura Corporation examined sovereign trading volumes reported by the Depository Trust Cleaning Corporation for late 2009 and 2010, finding that the vast majority of sovereign CDS contracts were traded fewer than five times per day (van Deventer 2012).[4] Five transactions per day falls well short of a liquid market—a fact that should be considered in assessing the information content of sovereign CDS spreads.

For spread decomposition to produce perfectly accurate default probability estimates, fixed income markets must perfectly reflect all available information. By implication, such analysis relies upon the strong form of the efficient-markets hypothesis (EMH) advanced by Eugene Fama (1970)—an idea that has often come under attack (e.g., Summers 1986, Crotty 2011). Most tests of EMH have involved equities rather than bonds. In a 2003 survey of EMH literature, Burton Malkiel (2003) identified only one study addressing bond-market efficiency, and that paper found inefficiency in the pricing of corporate bonds (Keim and Stambaugh 1986).

Since the trading volumes of large-cap stocks are much higher than those of municipal bonds, it is not clear that EMH applies at all to municipal bonds. There is a substantial literature documenting the lack of liquidity and transparency in the municipal bond market (see, for example, Chakravarty and Sarkar 1999; Harris and Piwowar 2006; Ang and Green 2011).

Bonds issued by larger sovereigns and sub-sovereigns do enjoy greater liquidity, but it is not clear that they trade based on their underlying credit fundamentals. In 2011, U.S. Treasury yields fell despite the failure of Congress and the Administration to agree on significant fiscal consolidation measures.

Even in the most liquid markets, bubbles and busts occur. When bubbles occur, market prices become detached from traditional measures of intrinsic value. Economists and other researchers have demonstrated skill in assessing intrinsic value and identifying the presence of bubble conditions. Robert Shiller (2000 and 2005) identified both the NASDAQ stock bubble and the real estate bubble using

4. Excludes inter-dealer trades.

such measures. Intrinsic-value analysis of financial assets dates back to the pioneering work of Benjamin Graham and David Dodd (1934) and John Burr Williams (1938), who suggested that stock prices could be benchmarked against measures such as the present value of future dividends and enterprise book value. Shiller (2005) considered building cost indices, price to rent ratios, and other benchmarks in support of his thesis of a property price bubble.

If government default probability and other valuation drivers can be derived independently from price, we can run the yield decomposition apparatus described earlier in reverse to determine intrinsic government bond yields and CDS spreads. Robust measures of fair value bond yields and CDS spreads would enable us to identify instances in which government credit markets are mispricing default risk.

Toward econometric modeling of government default risk

The literature contains a number of efforts to model sovereign bond defaults from fiscal, economic and political variables. For example, Paolo Manasse, Nouriel Roubini and Axel Schimmelpfennig (2003) fit a logit model on data from 37 countries between 1976 and 2001. They found the following variables to be statistically significant:

- Total External Debt / GDP
- Short Term Debt / Reserves
- Interest on Short Term Debt / GDP
- External Debt Service / Reserves
- Current Account Balance / GDP
- Openness
- US Treasury Bill Rate
- Real GDP Growth
- Inflation Volatility
- Inflation > 50 percent
- Presidential Election
- Freedom Index
- Lagged Crisis Indicator

Jens Hilscher and Yves Nosbusch (2010) created a logit model on a data set covering 31 countries from 1994 to 2007, which included 28 defaults. The variables they found to be statistically significant were:

- Volatility of Terms of Trade
- Change in Terms of Trade
- Years Since Last Default
- Debt / GDP
- Reserves / GDP

Because these models considered recent defaults prior to that of Greece, they only addressed emerging-market credit crises. It is only very recently—with the onset of the Eurozone crisis—that defaults among so-called "advanced economy" sovereigns were widely thought to be possible. An indication of the formerly prevailing wisdom is that Basel II rules included a zero risk weight on OECD sovereign debt. The zero-risk weighting meant that banks were not required to hold capital against OECD sovereign bonds, reflecting an assumption that they were default-risk free.

The last time that a significant number of government bond defaults occurred in what are now defined as advanced economies was during the 1930s. The most prominent defaults from this period in the wealthier Anglophone nations included:

Issuer	Year
Alberta (Province), Canada	1936
Arkansas (State), U.S.	1933
Australia *(bonds "voluntarily" swapped for lower rate issues)*	1931
New South Wales (State), Australia	1931
New Zealand *(bonds "voluntarily" swapped for lower rate issues)*	1933
United Kingdom *(made partial payment to U.S. on WWI debt)*	1933
United States *(abrogation of the gold clause)*	1933
Sources: *Moody's Government and Municipal Bond Manual*, *New York Times*, *Australia Year Book*, and *New Zealand Year Book* (details available from the author upon request).	

In all seven cases, interest expense as a percentage of total government revenue exceeded 30 percent. Relatively few large governments that reached ratios in excess of 30 percent avoided default, while all states, provinces, and commonwealths that stayed below this threshold continued to service their debts on time and in full.

The interest expense to revenue ratio normalizes a government's debt service burden against the government's capacity to harvest receipts from its tax base. The ratio has strong intuition. Unlike the debt/GDP ratio, it incorporates interest rates and systemic limits on a government's ability to extract tax revenues.

For an elected official the political cost of defaulting is quite high. It represents a serious embarrassment and it restricts the government's ability to finance future deficits through bond issuance. On the other hand, high levels of debt service crowd out spending required by key constituencies. The dilemma was captured in 1931 by Jack Lang, Premier of New South Wales, when announcing the state's default:

> Parliament in New South Wales was faced with an extremely awkward problem. It was committed to pay to oversea [*sic*] bondholders £700,000. The Government itself had not the money. It was informed, however,

> that this amount would be made available for shipment overseas if the Government needed it. Having in mind the reiterated statement that every £ of credit consumed by the Government meant a £ less for circulation among the primary and secondary industries, the Government was faced with a most difficult problem. If we took the £700,000 which the bank offered us, it meant that £700,000 worth of credit would have to be withdrawn from the primary and secondary industries of New South Wales. Default faced us on either hand. We could default, if we chose, to the farming community by withdrawing £700,000 from it, or we could default to our oversea creditors. Having to choose between our own people and those beyond our shores, we decided that the default should not be to our own citizens. (*Sydney Morning Herald* 1931, 11)

In making the default decision, officials balanced the interests of bondholders and voters/taxpayers. Such a tradeoff is represented by the interest expense to revenue ratio.

That ratio may be one of several metrics that could appear in a logistic model of sovereign, state, and provincial default risk. Further modeling will require the collection of more fiscal, political, and economic data from the 1930s and before.

Many resist the use of older data in modeling government default. Their objections are addressed by Carmen Reinhart and Kenneth Rogoff in a book whose title speaks to this very matter: *This Time Is Different* (2009). The authors state in the preface:

> Above all, our emphasis is on looking at long spans of history to catch sight of "rare" events that are all too often forgotten, although they turn out to be far more common and similar than people seem to think. Indeed, analysts, policy makers, and even academic economists have an unfortunate tendency to view recent experience through the narrow window opened by standard data sets, typically based on a narrow range of experience in terms of countries and time periods. A large fraction of the academic and policy literature on debt and default draws conclusions on data collected since 1980, in no small part because such data are the most readily accessible. (xxvii)

While Reinhart and Rogoff have collected an enormous amount of data in support of their research, the data set does not contain total government revenue, total government expenditure, and interest expenditure. Some of these data are available from the Center for Financial Stability's Historical Financial Statistics, but only for a limited number of countries for a limited number of years.

Public Sector Credit Solutions

To be effective, default models must be built upon large data sets. My group, Public Sector Credit Solutions, is enhancing the data collected by Reinhart, Rogoff, and the Center for Financial Stability. With the support of a research grant from the National University of Singapore's Risk Management Institute, we are creating a database of sovereign defaults, revenues, expenditures, debt levels, and debt service costs. The database will be freely available to anyone without registration.

Previously we collected data on U.S. municipal bond defaults between 1920 and 1939, which were summarized in Kroll Bond Rating Agency's (2011) inaugural municipal bond default study. We have also collected historical data on U.S. state defaults (Joffe 2012a) and Canadian provincial defaults (Joffe 2012b). New technologies have greatly simplified the task of collecting older government finance data. Many older references have been scanned and are available on line at Google Books, HathiTrust, and other websites. Hardcopy books can be photographed in libraries with high-resolution digital cameras rather than merely photocopied. Advanced optical character recognition (OCR) tools such as Abbyy FineReader facilitate the conversion of scanned or photographed images to usable text. When OCR produces unsatisfactory results, data from scanned or photographed documents can be entered by low-cost outsourcing teams based in developing countries. Collaboration with offshore providers has become easier with the advent of Dropbox and other cloud-based file sharing services.

More data will enable researchers to build better regression models, which can then be applied to current financial data to compute the default probabilities for today's government bond issuers. But any logit or probit model run against current fiscal and economic data will miss some important dynamics. Many advanced-economy governments face increases in pension and healthcare costs as populations age. Also, interest rates may remain low as they have for the last several years, revert to historical means, or go even higher, especially if market participants anticipate high levels of inflation. Academic economists are better equipped than rating agency analysts to estimate future social insurance benefit loads and to create reasonable distributions of future interest rates. Researchers can provide scholarly justification for the way they choose to incorporate factors related to policy, demographics, and macroeconomic events.

In recognition of this reality, Public Sector Credit Solutions has published an open-source tool that enables researchers to create and execute multi-year budget simulations. This tool, called the Public Sector Credit Framework (PSCF), also allows users to benchmark budget simulation results against a single default threshold or against a logit or probit model. In its basic mode the software counts the number of trials in which a user-specified threshold, e.g., an interest expenditure to total revenue ratio greater than 30 percent, is surpassed, divides that by the total number of trials, and presents the quotient as a default probability. Users can also produce agency-style ratings from the system by providing a default probability to rating map.

PSCF is free and open source. Users are welcome to download it, use it, request enhancements and implement them. PSCF models are also fully transparent so that they can be readily shared with and criticized by other members of the community. The Windows-based software and sample models are available on the PSCF web page (**link**). The source code, along with instructions about how to run a portion of the system under Linux, is available on an open source repository (**link**).

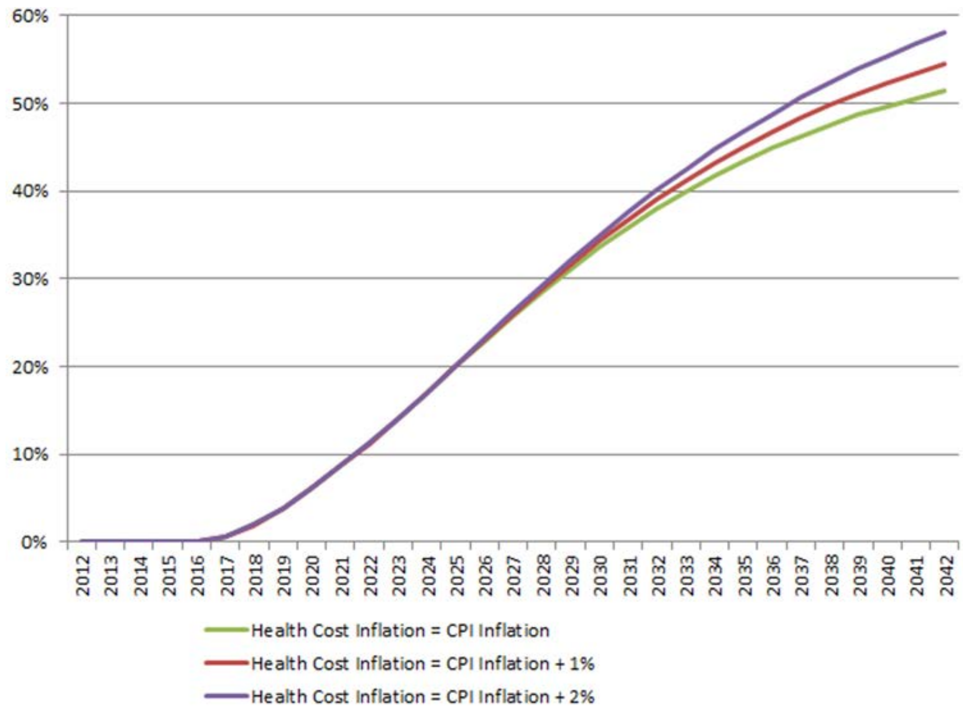
Along with the software, we released sample models for the U.S. Federal Government and for the state of California. Subsequently, we released a model for Italy. All of these samples are available on the PSCF web page.

The sample models provide implementation guidance, but the software itself is quite flexible. You can create any series you want, calculate future revenues and expenditures in any manner you deem appropriate, and use any default threshold ratio you wish. The core services offered by the software are random number generators (supporting uniform, normal and Cauchy/Lorenz, i.e., fat tail, distributions), the generation of simulations parameterized through an Excel front end, and simulation comparisons based on the user-supplied default threshold. A more advanced alternative allows the user to override the single ratio threshold with a C language code block that implements a probit or logit model. While the basic mode generates a binary default/no-default flag for each trial each year, the advanced option returns annual default probabilities between zero and one for each trial that are then averaged across all trials at the end of the simulation run.

With respect to forecast series, the U.S. and California sample models implement a demographic process based on the Lee-Carter mortality model (Lee and Miller 2001). Labor force participation and productivity growth are modeled as autoregressive processes. Random numbers generated in the framework are used to shock forecast rates of annual birth, death, labor force participation, and productivity. GDP growth is then derived from changes in the working age population, labor force participation, and productivity growth. GDP growth forecasts generated by the models tend to be lower than intermediate term historical averages due to lower workforce growth arising from baby-boomer aging.

Revenues are benchmarked against CBO and Legislative Analyst's Office (LAO) forecasts for the U.S. and California respectively. The projected revenues for each simulation trial are a function of the budget office GDP[5] forecast, the difference between the budget office's forecast and the GDP projected by the model for a given trial, and revenue elasticity of the source with respect to GDP.

Figure. U.S. federal fiscal crisis probability, defined as proportion of trials with (interest / revenue) > 30%.



In the U.S. model, expenditures generally conform to CBO projections for the first ten years. After that, Social Security, Medicare, and Medicaid costs are driven by demographic and inflation dynamics. In the sample, healthcare costs are assumed to rise 1% faster than consumer prices generally. But this assumption can be readily replaced with alternative scenarios. The figure above shows U.S. fiscal crisis[6] probabilities for three different scenarios: (1) health cost inflation equals CPI inflation, (2) health cost inflation exceeds CPI inflation by 1% annually, and (3)

5. In the California model, personal income is used in lieu of GDP, but personal income is represented as a fixed percentage of Gross State Product.
6. In deference to those who contend that an outright U.S. treasury default is impossible, we use the term "fiscal crisis probability" in lieu of "default probability". This terminology recognizes that monetization may take the place of outright default.

health cost inflation exceeds CPI inflation by 2% annually. A white paper supplied on the PSCF software page explains how other series were modeled in the samples.

The models we have provided represent only one recommended approach. The transparency of the models and the free availability of the source code underlying the framework are intended to start a conversation among economists and software architects about how best to approach the matter. My hope is that potential users see PSCF not as "Marc Joffe's government default model", but rather as a starting place to create their *own* government default probability models. Further, the open source software itself should become the property of a larger user community that develops and improves it. I welcome an academic department to adopt the open-source project and ask its economics and finance students to improve the software implementation.

Conclusion

As we've seen in Greece and Argentina, sovereign credit crises in relatively high-income nations are disasters. Debt crises force fiscal consolidations. People who are dependent on government salaries and benefits suffer drastic reductions in their living standards. Public sector employees and aid recipients respond with a mixture of despair and protest. When protests become violent, the results are extensive property damage, injuries, and deaths. Since these crises may spread to other OECD sovereigns and sub-sovereigns, the task of estimating their likelihood is an important research question. I invite researchers to explore our historic data and the Public Sector Credit Framework in their pursuit of better tools, better analysis, and better assessments of government credit risk.

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