Public Financing Under Balanced Budget Rules*

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February 16, 2025

Abstract

This paper analyzes the impact of a balanced budget rule (BBR) on government financing costs and its implications for the government balance sheet. Exploiting the variation in BBR implementation across US states, we find that states with more stringent BBRs exhibit significantly lower bond spreads and credit default swap spreads, demonstrating the crucial role of default risk. A sovereign default model, which features long-term debt, endogenous investment and output, as well as a BBR, aligns with the empirical result. Calibrated to Illinois, our quantitative analysis suggests that implementing a BBR could dramatically decrease the state bond spread, gradually lower the debt, and improve welfare in the long run.

Keywords: Public financing, balanced budget rule, sovereign default risk, state government, fiscal rule

JEL classification: E62, F34

*We are grateful to the editor and referees for their constructive comments and valuable suggestions. We also thank Siddharth George, Pablo Guerron-Quintana, Hewei Shen, Jianpo Xue, Livia Yi, Krishna Pendakur, as well as seminar/conference participants at SUFE, World Bank EAPCE Research Centre, 2022 AMES (Tokyo) and Annual Meeting of CMSG for helpful comments and feedback. Minjie Deng acknowledges the support from the SSHRC Insight Development Grant (430-2022-00205). Chang Liu acknowledges the support from NUS Start-up Grant (A-0003734-00-00). Xiaolin Gong and Kyeongmin Park provided excellent research assistance.

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1 Introduction

The European debt crises brought to the fore the importance of sustainable public finances in avoiding a government crisis. Before 1990, only a limited number of countries had implemented fiscal rules. As of 2021, this number has risen dramatically with more than 100 countries now having fiscal rules in place.[1] This increase reflects a growing global recognition of the need to curb a sovereign's tendency to overspend, a sentiment that has been documented in various studies (e.g. Alfaro and Kanczuk, 2017). The COVID-19 pandemic has led to a new wave of fiscal expansions, causing an increase in the debt burdens of many countries and regions. This has resulted in a resurgence of discussions surrounding the impact and optimal design of fiscal rules (e.g., Blanchard et al., 2021). It is of utmost importance to evaluate the effectiveness of these rules to inform practical policy debates.

The International Monetary Fund (IMF) defines a fiscal rule as a long-term restriction on government financial policy through numerical limits on budget aggregates. Fiscal rules come in various forms, including budget balance rules, debt rules, expenditure rules, and revenue rules (Lledó et al., 2017). In this study, we focus on budget balance rules (BBRs) and explore the impact of this fiscal rule on public financing, specifically on government financing cost. Our research findings show that US states with BBRs have significantly lower debt spreads, which is attributed to their lower default risks. To illustrate the mechanism and further examine the effects of BBRs, we construct a sovereign default model that incorporates a BBR, defined as a requirement that government revenues must be sufficient to cover government spending and interest payments. We quantitatively demonstrate that the implementation of such a rule results in reduced government borrowing, lower bond spreads and improved welfare in the long run.

Previous studies have pointed out that BBRs can reduce governments' propensity to run deficits and lead to more sustainable public finances. However, little is known about the nexus between BBRs and government financing costs. On the one hand, fiscal rules like the BBRs tend to restrict fiscal policies, thereby restricting the government's ability to increase future output via public consumption and investment expenditures, which tends to increase the risk of default. On the other hand, a government committed to fiscal rules is discouraged from excessive borrowing and running deficits, which improves future balance sheet and reduces the risk of default. We empirically explore the link between BBRs and government debt spreads by exploiting policy

[1] IMF Fiscal Rules dataset 1985–2021.

variation both across US states and across time. This approach is more favorable than existing cross-country or time-series studies because some of the potential missing factors driving debt spreads in these studies can be captured by the fixed effects in our setting.

The state governments in the US are treated as sovereign entities—they can design their own fiscal rules, issue bonds, and may also default on their bonds. Unlike most previous studies that treat BBRs as a time-invariant factor (generally due to limited data), our analysis is based on a hand-collected dataset on state government BBRs that covers multiple years and a number of BBR policy changes. This dataset shows a substantial variation in BBRs across states at both the extensive and intensive margins: 20–30% of the states have not imposed any deficit carryover restriction, and for those that do have a BBR in place, there is substantial variation in their tightness, e.g., whether the rule is constitutional or statutory. In addition, we observe a large variation in government bond spreads both across states, with magnitude comparable to those of European countries, and across time, implying the presence of state and time-specific factors underlying government bond prices.

In our empirical analysis, we control for a variety of factors that could potentially affect the relationship between BBRs and debt spreads. These include bond-specific characteristics, state-level economic and fiscal conditions, as well as time and state fixed effects. We consider both ordinary least squares (OLS) and instrumental variable (IV) approaches. We use past state government surpluses as the IV, with the identification assumption that past government budgets are correlated with changes in BBRs (because policies can react to past budget conditions) but are arguably not related to the residual factors that drive current government bond prices (because bond prices are forward-looking), with the caveat that this approach may underestimate the policy impact if past budget condition reveals the government type which can also be related to government borrowing costs. Estimation results of both approaches show that BBRs are significantly negatively correlated with state bond spreads. This result holds across different measures of BBRs and is also robust to adding additional control variables that may correlate with both the time-varying BBRs and bond spreads. We then provide evidence that default risk is likely to be an important channel through which BBR affects borrowing costs. Our BBR measures are also significantly negatively associated with state government credit default swap (CDS) spreads, a direct measure of the default risk component of state government bond spreads. This suggests that BBRs reduce borrowing costs by lowering default risk.

To better understand the empirical results, we introduce a BBR in a quantitative sovereign default model with capital accumulation. In our framework, the government makes investment decisions, borrows by issuing state-uncontingent bonds, and can choose to default on these bonds. The bond price reflects the magnitude of the government default risk. We then build on this default model by considering an institutional setup in which governments are required to execute a BBR, which is modeled as a requirement that government revenues must be sufficient to cover government spending and interest payments. Theoretically, a BBR can diminish government spreads by imposing a limit on government borrowing, thereby reducing bond spreads. However, it can also hinder the government's ability to borrow in promising opportunities, potentially leading to reduced future output and increased bond spreads, compared to scenarios without a BBR. Quantitatively, we find that the first channel dominates, indicating that a BBR on net effectively reduces default risk, lowering the cost of government financing.

In the quantitative analysis, we calibrate the model using data on Illinois, a state with weak fiscal conditions, high borrowing cost and no BBR in place. First, we replicate our empirical result using model-generated data. We find that the regression result is broadly consistent with the empirical findings using real data: the implementation of a BBR is associated with lower government spreads. Second, we simulate the dynamics of key government finance variables and the bond spread should a BBR be imposed in Illinois. We find that, a decade after the introduction of a BBR, the bond spread decreases significantly from 2.3% to 0.3%, with the largest impact occurring immediately. The debt-to-GDP ratio declines gradually from approximately 9.2% to 2.6%, together with gradual declines in debt-to-tax-revenue ratio and interest payments. We also find that introducing a BBR can generate welfare gains in the long run, because lower borrowing costs and debt burdens free up resources for consumption and investment activities. In the short run, however, the BBR lowers aggregate welfare due to the tightened fiscal capacity.

Taken together, our empirical and quantitative findings highlight the often-overlooked role of fiscal rules in determining government bond prices (including those of municipal bonds). These findings underscore the importance of implementing fiscal rules in shaping the dynamics of government balance sheets. We make two primary contributions to the literature. First, we are the first to link time-varying BBRs with government financing costs at the US state level thanks to a novel dataset of different measures of BBR and comprehensive data on state government bond markets.[2] By doing so, we show that fiscal rules can be an important factor in affecting asset prices in the government bond market. Second, we establish a new quantitative framework that incorporates both BBR and default risk—a feature that distinguishes this paper from the existing literature on the quantitative analysis of BBRs—to shed light on the mechanism underlying this empirical link and to facilitate quantitative analysis.[3]

Literature. Empirically, this paper contributes to the literature on the impacts of BBRs at the state level. This literature mostly focuses on the effects of BBRs on a state's budget surplus or deficit. BBRs have significant positive effects on a state's budget surplus (Bohn and Inman, 1996). When deficits occur, a BBR leads to more rapid fiscal adjustments by tax increases and spending cuts to restore fiscal balance (Poterba, 1994, 1996; Hong, 2015). However, the benefits of fiscal balance must be weighed against the possible costs of compromising fiscal policy's ability to stabilize business cycle fluctuations (Eichengreen and Bayoumi, 1994). Empirical evidence for the adverse effects of BBRs on a state's stabilization policy is mixed. A lower cyclical variability of the budget balance does not necessarily lead to higher volatility in output (Alesina and Bayoumi, 1996; Krol and Svorny, 2007), and BBRs can reduce fluctuations in output, compensating for less responsive fiscal policy with reduced volatility in fiscal policy (Fatás and Mihov, 2006). We focus on the effects of BBRs on state borrowing costs measured by state government spreads beyond indebtedness or deficits. In addition, our data set on state-government BBRs is constructed in a similar way to Canova and Pappa (2006) and Bohn and Inman (1996), but we also allow the time-variation in these rules.

Our argument that BBRs can lower the required return on state bonds by reducing default probabilities is in line with Eichengreen and Bayoumi (1994), who show that fiscal restraints lower the required return on general obligation bonds by nearly 50 basis points. Relatedly, Poterba and Rueben (2001) show that while unexpected deficits are correlated with higher state bond yields, the effect is smaller for states with tight anti-deficit rules. Recent literature also explores government default risk and borrowing costs using state-level spreads (Arellano et al.,

[2] Poterba and Rueben (1999) study the effect of fiscal rules on the yields of state general obligation bonds, but using only survey data on the estimates of bond yields by bond traders at major brokerage houses instead of their actual realized values. In addition, they assume time-invariant BBRs that we show is strongly counterfactual. Feld et al. (2017) conduct a similar exercise for Swiss cantons. They empirically document that strong and credible BBRs in Swiss cantons contribute to lower risk premia. By restoring financial market confidence, a BBR contributes to a decrease in risk premia by more than 10 basis points.

[3] Azzimonti et al. (2016) study the impact of BBR on debt, taxes, expenditures, and welfare in a political economy framework. Our empirical analysis shows that default risk is an important channel through which BBR has an impact, and therefore we build a model with default risk.

2016; Deng, 2024), while our paper investigates how they are driven by fiscal rules.

Our research also relates to the literature on how BBRs impact financial outcomes of national governments. In earlier studies, national fiscal rules among Eurozone and OECD countries show a very weak effect on bond spreads (see, e.g., Iara and Wolff, 2014; Heinemann et al., 2014; Kumar et al., 2009), which implies that these fiscal rules are either not strong or not sufficiently credible to affect investor risk assessments. Asatryan et al. (2018) finds that the introduction of a constitutional BBR reduces the probability of a sovereign debt crisis. Our contribution is to expand the study to a subnational level by constructing new measures of state government BBRs, and investigating their impact on state government borrowing costs. A cross-state analysis is more desirable than a cross-country one because nationwide factors can be absorbed in time-fixed effects in the former, while heterogeneity across countries is harder to control for in the latter. Nonetheless, our result has clear implications for national fiscal policies as well.

Theoretically, our framework is related to the literature exploring the impact of fiscal rules in the context of sovereign debt and default (e.g., Alfaro and Kanczuk, 2017; Hatchondo et al., 2022). Alfaro and Kanczuk (2017) find that a simple debt limit yields a welfare gain close to that of optimal fiscal policy and performs better than a deficit rule. Hatchondo et al. (2022) evaluates common fiscal rules for a union of heterogeneous model economies in a sovereign default model. They find that in contrast with a common debt brake, a common spread brake generates welfare gains for all economies in the union. Different from theirs, our work focuses on the impact of a BBR on government borrowing cost together with its implications for public financing in general. Our paper is also related to the sovereign default models with capital accumulation (see, e.g., Gordon and Guerron-Quintana, 2018, Arellano et al., 2018, Deng and Liu, 2024). With the existence of capital accumulation, the impact of a BBR on government spreads has a counteracting force because a BBR can hinder the government's ability to borrow and accumulate capital in promising opportunities, potentially leading to reduced future output and increased bond spreads.

The remainder of this paper proceeds as follows. Section 2 constructs and describes our measures of BBR and state government bond spreads. Section 3 conducts empirical studies on the impact of BBRs on government spreads. Section 4 presents a sovereign default model with a BBR. Section 5 parameterizes the model using Illinois data and quantitatively studies the impact of introducing a BBR. Section 6 concludes and discusses various implications of lower government financing costs. The Appendix provides details on data cleaning, construction, additional empirical results, computational methods, and additional quantitative results.

2 Data and Summary Statistics

2.1 Data Construction

Measuring BBRs. Our first contribution is to build a consistent dataset capturing several measures of state government BBRs. While there is no consensus on how to measure the tightness of state-level BBRs, there are two general approaches: examining deficit carryover restrictions or legal requirements. The former is more clear-cut, requiring that the state cannot carry over any deficit at year-end. It can be seen as a form of ex-post restriction that prohibits the government from running deficits, even if the economy needs more debt financing. Legal requirements, however, are ex-ante rules imposed by the legal system which take various forms in practice. For example, in the 2021 *Budget Processes in the States* report published by the National Association of State Budget Officers (NASBO), legal restrictions include "governor required to submit balanced budget", "legislature required to pass balanced budget", and "budget signed by governor required to be balanced." Furthermore, in each category, the requirement can be "constitutional" or "statutory", which carry different legal weights. Measurement of BBRs, both by the public media and by academic literature, focuses on different aspects of the two categories. For example, the Urban-Brookings Tax Policy Center defines a "strong" balanced budget requirement for a state as meeting one or more of the following criteria: governor required to sign a balanced budget, prohibited from carrying a deficit into the following year, or the legislature required to pass a balanced budget accompanied by within-year fiscal controls or limits on supplemental appropriations.[4] Costello et al. (2017), however, simply defines BBR as a dummy variable that is equal to 1 if the state has a "no-carry-forward" rule and 0 otherwise, citing that deficit carryover restrictions are the most rigorous and effective means of reducing deficit spending.

Our primary measure of BBR follows this idea, that is, a state is considered to have a BBR if they are not allowed to carry over a deficit from one fiscal year to another. Different from most previous studies where BBR is measured as a fixed characteristic of a state (e.g. Poterba and Rueben, 2001; Clemens and Miran, 2012; Costello et al., 2017), we highlight state-level policy changes over time. To do so, we collect data from NASBO's *Budget Processes in the States* report,

[4] https://taxpolicycenter.org/briefing-book

Table 1: BBR Across US States

	1986	1988	1991	2007	2014	2020
No Deficit Carryover (#)	40	41	37	43	39	36
ACIR Index 0-10 (avg)	8.33	8.54	8.04	8.84	8.22	8.12
Correlation	0.93	0.97	0.97	0.96	0.95	0.97

Notes: The first line summarizes the number of states that imposed a no-carryover rule in each year. The second line presents the average ACIR index across states. The third line shows the correlation of our two measures of BBRs: dummy and index.

published in 1987, 1989, 1992, 2008, 2015, and 2021.[5] This report is also the standard reference source for BBR information in the *Book of the States* for most years.[6] Because of the lag between the survey and publication dates, we use the information in each publication to measure the BBR of the previous year.

Our second measure of BBR borrows from the approach of *Fiscal Discipline in the Federal System: National Reform and the Experience of the States* published by the Advisory Commission on Intergovernmental Relations (ACIR) in 1987, which establishes a point system to construct an index for each state's BBR conditions. Our ACIR-inspired index calculates the degree of BBR stringency based on the total number of points assigned to each category of the aforementioned balanced budget requirements. Similar to the original publication, our index assigns points for whether the governor must submit a balanced budget (1 point), the legislature must pass a balanced budget (2 points), or if the state cannot carry a deficit into the next fiscal year (8 points). The index value is then set equal to the points from the "highest-ranked" requirement among these three, plus 1 point if the rule is statutory or 2 points if the rule is constitutional. The result is an index ranging from a minimum of 0 if a state has no BBR legislation, to 10 points if a state does not allow for deficit carryover and this requirement is constitutional or both statutory and constitutional.

BBR Across States. The third line of Table 1 shows that our two BBR measures are highly correlated, which is not surprising given the heavy weight we put on deficit carryover. The first line summarizes the number of states that imposed a BBR requirement in each observed

[5]The 1997, 1999, and 2002 reports do not contain information on whether a state can carry forward its deficit, so are excluded from our sample.

[6]In the 1992, 1995 and 1997 editions of the *Book of the States*, "State Balanced Budgets" are updated by The Council of State Governments, reflecting literal readings of state constitutions and statutes. To build a consistent sample using a uniform definition, we omit these updates from our BBR sample. However, adding these years does not alter the significance of our baseline results.

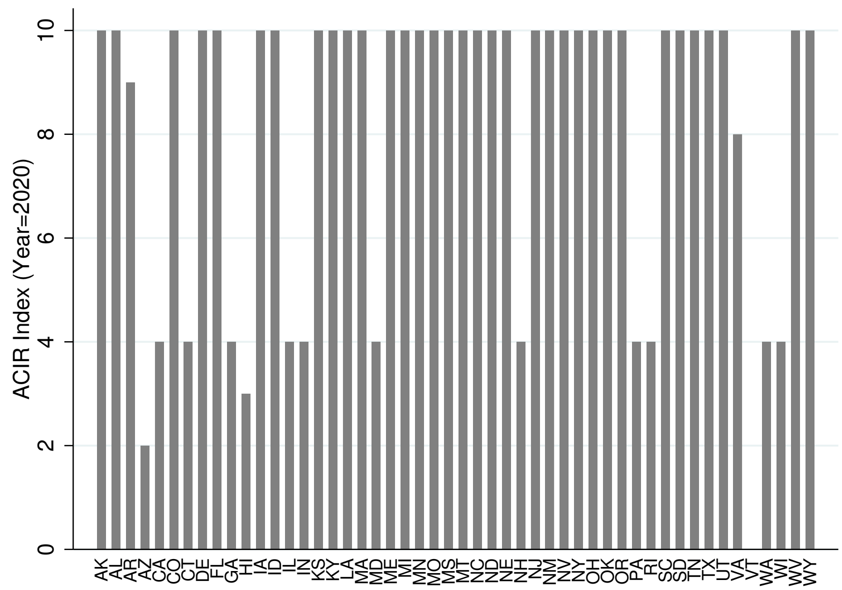


Figure 1: ACIR Index in 2020

Notes: ACIR Index in the year of 2020 by state, from 0 (no BBR) to 10 (strictest form of BBR).

year. While the majority of states had a "no-carryover rule" in place, some states did not. The second line shows that, consistent with the first measure, the index measure has a high average value, indicating that most states have some form of BBR. Figure 1 presents a snapshot of the geographical distribution of BBRs in 2020. While many states have very tight BBRs—an index of 10 or close to 10—there are a number of states with very loose requirements. For example, the state of Illinois does not forbid carryover of deficit into the next fiscal year, but only requires that the legislature must pass a balanced budget. In Section 5, we explore the impact of a tighter BBR legislation in Illinois.

BBR Across Time. In the literature, BBR is generally taken as time-invariant (e.g. Poterba and Rueben, 2001; Costello et al., 2017; Clemens and Miran, 2012), whereas throughout our sample, changes in the tightness of BBRs were very common. This is reflected both in the time-variation in the number of states that imposed "no deficit carryover" rules and in the average ACIR index, shown in Table 1—fewer states imposed this rule in the last decade than the previous ones, and the average index tended to be smaller in the recent decade, revealing a general trend of relaxed BBRs among states. To present the time-variation in BBRs, we plot the histogram of the number of BBR changes, that is, the occurrence of switches between "BBR" and "no BBR" in each state when we apply the "no deficit carryover" rule. Figure 2 shows that nearly half of the states

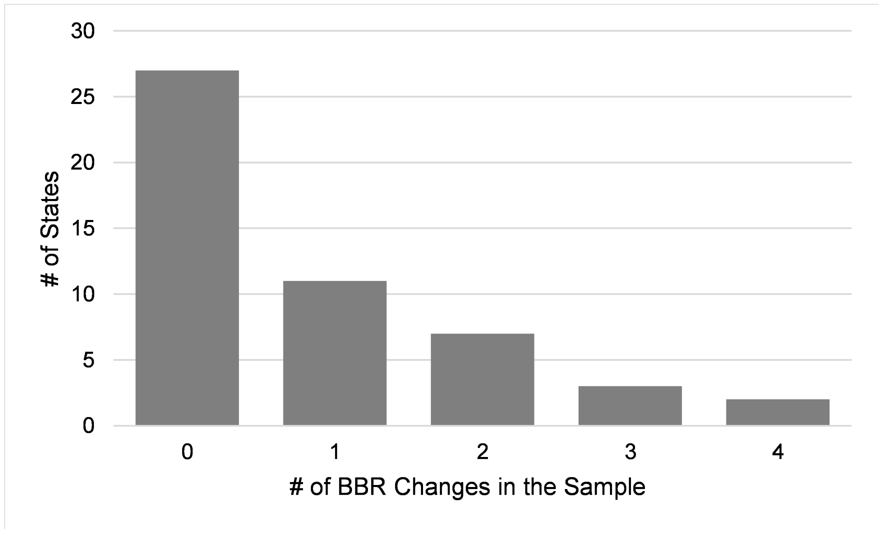


Figure 2: Histogram of the Number of BBR Changes Over Time

Notes: This graph plots the histogram of the number of BBR changes over time, that is, the number of changes in the dummy variable (the first BBR measure) from 0 to 1 or from 1 to 0 in each state in our sample.

experienced at least one change in BBR in our sample. A number of them had more than one switches in the "no deficit carryover" rule. This observation makes policy evaluation of BBRs in the literature potentially problematic, which typically assumes BBRs to be time-invariant. In our empirical exercise, we discuss various ways to account for potential endogeneity of BBRs and show how the time dimension can help identify the impact of BBRs on government debt spreads.

Measuring State Government Bond Spreads. Our data on municipal bond issues come from the Securities Data Company's (SDC) Global Public Finance US Municipal New Issues database, which contains detailed information on various characteristics of newly issued bonds at the state and local levels, including issuer information, size of issue, years to maturity, coupon, prices, yields, and credit ratings, among others. Unlike transaction-level municipal bond price data, such as the Municipal Securities Rulemaking Board (MSRB) dataset used in Ang et al. (2014) and Schwert (2017), our SDC data contain only newly issued municipal bonds.

To construct a clean and reliable dataset, we follow common data selection steps documented in the literature such as those promulgated by Novy-Marx and Rauh (2012), Schwert (2017) and Butler and Yi (2022). First, we omit observations that are most likely to contain data errors. Second, we focus only on general obligation bonds that are unsecured by any special-purpose revenue. Third, we include only bonds with fixed coupon rates to accurately calculate bond spreads. Fourth, we winsorize all yield and yield spread variables at 1% and 99% over the sample period to mitigate the impact of outliers. More details on our data cleaning methods are relegated to Appendix A.

Following the procedures above, our dataset contains general obligation bonds issued by US states (including DC), counties, cities, and other government entities from 1976 to 2020. As this paper focuses on the relationship between state government fiscal rules and financing costs, we keep only the state government bonds. Additionally, as most municipal bonds are exempt from federal and state taxes, it is important to account for tax rates as a source of variation in bond yields in the cross section. Therefore, we adjust the state bond yields by a tax adjustment factor $\tau_{s,t}$ specified as $1 - \tau_{s,t} = (1 - \tau^{fed}_{s,t})(1 - \tau^{state}_{s,t})$, where $\tau^{fed}_{s,t}$ and $\tau^{state}_{s,t}$ denote the top federal and maximum state income tax rates using data from NBER TAXSIM.[7]

State bond spreads are calculated as the difference between the tax-adjusted yield of a state government bond, readily available from our dataset or calculated from the raw price if the information on the yield is missing, and a tax-adjusted synthetic yield, constructed using the corresponding term structure together with the treasury spot rates estimated in Gürkaynak et al. (2007), following the method described in Butler and Yi (2022). The result of this approach is a tax-adjusted spread that depends on the term and coupon structure of each bond issue. In the empirical analysis, we account for the spread variation caused by this difference by controlling for coupon and maturity in our regressions.

Table 2 provides a description of the dataset used in the empirical analysis. Our sample consists of more than 7,000 observations of bonds issued by state governments, mostly from 1980 to 2020 (with only 3 in 1977, 2 in 1978 and 2 in 1979). There are significant variations in all the variables that we consider. In particular, the key dependent variable, State Bond Spread, has a mean of 0.772% and a standard deviation of 0.788%. The primary goal of this paper is to understand this considerable variation in state government borrowing costs across states and over time.

Other State-Level Variables. We also include state-level economic, fiscal, and political variables as controls in our regressions. Annual state-level GDP data are taken from the BEA Regional Economic Accounts, and they are divided by state total population to obtain state GDP per capita. The fiscal variables of the state government—debt at the end of the fiscal year, total revenue, and total expenditure—are all from the Annual Survey of State Government Finances.

[7] This tax adjustment factor is the same one as in Schwert (2017), consistent with previous literature that estimate the marginal tax rate implied by municipal bond prices.

Table 2: Descriptive Statistics of State Government Bonds

	(1) **Mean**	(2) **Median**	(3) **S.D.**	(4) **P1**	(5) **P99**	(6) **N**
Maturity	2.679	1.000	4.315	0.250	24.083	7,027
Coupon	4.470	4.500	2.159	0.350	11.000	7,027
Amount (million $)	179.935	63.000	458.433	0.760	1,968.930	7,027
Taxable Bonds (%)	11.755	0.000	32.209	0.000	100.000	7,027
Price	102.510	100.937	4.365	99.283	124.398	7,027
Yield (%)	3.107	3.099	2.023	0.150	8.750	7,027
Tax-Adjusted Yield (%)	2.332	2.121	1.739	0.033	6.995	7,027
State Bond Spread (%)	0.772	0.567	0.788	-0.696	3.776	7,027
Fitch Rating	1.038	1.000	0.340	1.000	3.000	453
Moody's Rating	1.072	1.000	0.481	1.000	4.000	512
S&P Rating	1.152	1.000	0.596	1.000	4.000	488
Overall Rating	0.014	0.000	0.052	0.000	0.222	537

Notes: This table presents the mean, median, standard deviation, 1st percentile, 99th percentile and total number of observations (excluding missing data) of each variable. We map rating notches into numerical values, where 1 is the highest rating (Aaa or AAA), 2 the second highest (Aa1 or AA+), and so on. "Overall Rating" is the average of the three normalized rating scores (Fitch, Moody and S&P). We use the average of the three normalized rating scores to represent the final rating score of each bond, though only about 1/5 of our sample bonds are rated.

Table 3: Average Spread: BBR States v.s. No-BBR States

	1986	1988	1991	2007	2014	2020
No Deficit Carryover	1.35	0.32	0.74	1.06	0.21	0.52
Deficit Carryover Allowed	1.60	0.12	0.92	1.01	0.66	0.80

Notes: The first row presents the average state bond spread (in %) across states with BBR (based on the "No Deficit Carryover" measure). The second row shows the average state bond spread across states without BBR.

2.2 BBR and State Government Bond Spreads

Before moving on to regression analysis, we start by presenting the comparison of average state bond spreads for states with and without BBR, based on our primary BBR measure defined as "No Deficit Carryover". With the caveat in mind that there may be confounding factors that also drive the difference in spreads across states, Table 3 reflects that among the six years when we have BBR data, in four of them the average spread for BBR states is much lower than their no-BBR counterparts, with the year of 1988 being an exception and in 2007 the two averages are quite close.

3 Empirical Study

In this section, we present our main empirical results on whether imposing a BBR would affect the financial cost of a state government. We further provide evidence of the important role that default risk plays in driving this relationship.

3.1 Empirical Specification

Our baseline estimation is specified as follows:

$$\text{Spread}_{i,s,t} = \text{constant} + \beta^{\text{BBR}} \times \text{BBR}_{s,t} + \boldsymbol{\beta}^{\text{control}} \times \boldsymbol{X_{i,s,t}} + \gamma_t + \theta_s + \varepsilon_{i,s,t} \tag{3.1}$$

where $\text{Spread}_{i,s,t}$, the state government bond spread for state s and year t at each issuance i, is our primary dependent variable. In our baseline regressions, $\text{BBR}_{s,t}$ denotes either the dummy variable of whether a state can carry over its deficit (examining the extensive margin) or the ACIR index described in Section 2.1 (examining the intensive margin). In the appendix, we also consider another BBR measure as a robustness check.

$\boldsymbol{X_{i,s,t}}$ is a vector of control variables that includes the characteristics of bond issuance (maturity and coupon) and state-level variables (debt-to-GDP ratio, GDP growth, total revenue-to-GDP ratio and total expenditures-to-GDP ratio). As our construction of $\text{Spread}_{i,s,t}$ cannot eliminate the differences in the coupon and term structure between issues, we control for the specific characteristics of the bonds. In the sovereign default literature, two key variables driving government borrowing costs are its debt level, measured by the debt-to-GDP ratio, and its economic condition, measured by output growth. Intuitively, a sovereign with a larger debt position is more likely to default because the benefit of default is likely to be larger, while one with higher economic growth is less likely to default because of relatively higher default costs. Besides these variables, we also control for government revenues and expenditures because they could also potentially affect state spreads. A government with a strong fiscal position—that generates more fiscal revenue or spends less—may be considered by investors as less likely to default on its debt. With all these potential driving forces of the state government spreads controlled for, our key coefficient of interest is β^{BBR}.

Our sample is an unbalanced panel because there are instances of multiple bond issuances for a given state in one year or no bond issued for a state-year pair. Aggregating into a state-year sample would miss information on the variations across each issuance that are useful for identification. We consider state and year fixed effects to capture any unobserved differences across states (such as political institutions, financial market openness, etc.) that might have influenced the cross-sectional variation in bond spreads, and any unobserved time-varying nationwide factors (such as time-varying risk aversion, monetary policy changes, nationwide fiscal policy changes, inflation, inflation expectations, etc.) that might have contributed to the variation in bond spreads over time.

Equation (3.1) can also be seen as a generalized difference-in-difference regression, where β^{BBR} measures the average treatment effect (as in Asatryan et al., 2018). As with any other DID estimation, an important concern that might threaten a correct identification is that policy changes may be endogenous. There are three potential ways to address it. First, one could check the trends in the dependent variable $\text{Spread}_{i,s,t}$ in the years leading to the introduction of BBR to see if past fiscal and economic outcomes affect the probability that a state adopts a BBR. However, this exercise is infeasible in our setting because our sample of BBR is discontinuous, with data available for only a limited number of years. Second, one could add additional controls, including fixed effects and other control variables that may drive the dependent variable, to minimize the bias due to omitted variables. In our robustness tests, we add more control variables (in addition to the fiscal control variables and fixed effects presented in the baseline result). Third, a good IV for BBR would also help to address the endogeneity issue. In our baseline exercise, we take this approach using lagged state government surplus as the instrument. In doing so, we rely on the identification assumption that: (1) changes in BBRs are potentially correlated with past government budgets because a change in the fiscal rule is likely the response to government budget conditions, and it takes time for a new policy to be enacted (hence the lag); and (2) past government budget conditions are arguably unrelated to the residual factors that drive today's government bond prices—satisfying both the exogeneity and relevance conditions.[8]

3.2 Results

Table 4 presents our main empirical findings using least squares estimations (Panel A and B) and IV estimations (Panel C). In all of the specifications, we consider debt-to-GDP ratio, per capita

[8] Using lagged macro variables as instruments is a common approach to address endogeneity in the empirical macro literature, dating back to Hansen (1982). Similar to us, Kumar and Baldacci (2010) use lagged values of the fiscal balances to instrument for current fiscal conditions. However, the exclusion restriction may not hold if we allow past information about fiscal accounts to reveal a government's type in an incomplete information framework. We discuss this caveat in detail in Section 3.2.

GDP growth and year fixed effects. We add fiscal control variables spending-to-GDP ratio and revenue-to-GDP ratio in columns (2) (4) (6) and (8). We add state fixed effects in columns (3) (4) (7) (8) (10) and (12).

Let us first focus on the results for our preferred specifications under a least squares approach, which include all the control variables together with both state and year fixed effects, shown in columns (4) and (8). Estimates of the BBR coefficient are negative and significant at (at least) the 10% level for both specifications. Column (4) shows that imposing a "no deficit carryover" BBR would, on average, lead to a 0.166 percentage point decrease in state bond spreads. The estimate is harder to interpret for the Panel B results, because a one numerical point increase in the ACIR index does not carry a natural interpretation. Nonetheless, it provides additional evidence for the negative relationship between BBR and state government financing costs. The estimates for the coefficients of the main control variables are very similar across the two panels. The debt-to-GDP ratio is positively and significantly associated with spreads, consistent with the predictions of standard theories. The coefficients on GDP growth are negative—again consistent with theory—yet not significantly different from 0 in our sample. Coefficients on the bond-level controls, maturity and coupon, are both anticipated to be significantly positive by construction. Adjusted R-squares in both regressions are greater than 0.4, indicating that the right-hand side variables included in our baseline specifications have strong explanatory power.

Our main result is robust to other specifications, as shown in columns (1)–(3) and (5)–(7). For example, taking out the fiscal control variables does not affect the magnitude or significance of our key estimates, as shown in columns (3) and (7). Including only time fixed effects, as shown in columns (2) and (6), does not alter the sign of the BBR coefficients or their magnitudes. The BBR coefficient turns slightly insignificant at the 10% level when the BBR variable takes the ACIR index, but its sign remains negative. Columns (1) and (5), reporting the estimation result when neither the fiscal variables nor the state fixed effects are included, yield a similar conclusion. Across all specifications, the magnitudes and signs of the control variable coefficients are also very similar. Overall, the OLS regressions consistently find a negative and significant relationship between state bond spread and BBR. They also suggest that both time and state fixed effects are important in understanding the variation in state bond spreads across states and over time.

In Panel C, we report the IV estimation result using the two-year lagged government budget surplus as the IV. We exclude the fiscal control variable in these estimations to avoid the colinearity problem. We estimate (3.1) using a two-stage-least-squares (2SLS) approach. First-stage results in Table B.1 provide evidence that our measures of BBR are indeed likely to be endogenous to past government budget surplus: higher government surpluses are negatively associated with both measures of BBR. All of the four specifications pass the weak IV test with higher Cragg-Donald Wald F-stats than the Stock-Yogo critical values.

Three observations stand out from our second-stage IV estimates. First, the coefficient on BBR remains significantly negative, no matter which BBR measure we use or whether both fixed effects are included. Second, estimates of the coefficients on control variables are similar to their OLS counterparts. Third, the BBR coefficient estimates under the IV approach can be one order of magnitude larger than those under OLS. On the one hand, it indicates that the OLS estimates are potentially biased; on the other hand, the finding in the IV estimation only strengthens our argument for the negative link between BBR and state bond spread.

Discussion of IV result. As discussed above, the validity of our IV relies on two conditions: past government budget conditions affect the current implementation of a BBR (relevance), but are not correlated with the residual term that drive current government debt spreads (exogeneity). While the relevance condition is supported by the first-stage results, the exclusion restriction can be debatable. The view supporting this exogeneity condition is that asset prices are more forward looking, corroborated by the empirical literature that find *expected* fiscal balances to matter more than *past* ones in driving government bond yields (e.g., Kumar and Baldacci, 2010). Another view, however, is that past fiscal surpluses could convey information about the government type in an environment with incomplete information, that is, a government may be perceived as more credible if there's stronger past government surplus which leads to lower borrowing cost. Together with the negative point estimate of β^{BBR} and the negative covariance between fiscal surplus and BBR, our IV approach tends to underestimate the true impact of BBR on government spreads. These two views combined, we argue that our IV estimate provides a lower bound on the negative impact of BBR on state government bond spreads.

It's also worth noting that there's a sizable difference between our OLS and IV estimates. This suggests that the OLS estimation has likely suffered from endogeneity problems. Based on our discussion above, fiscal rules may be endogenously adopted by less-disciplined governments which can be associated with higher financing cost. As such, the unobserved government type can be an omitted variable that causes an upward bias of the OLS estimate. That considered, we therefore prefer the IV estimations that consider two-way fixed effects as shown in columns

(10) and (12). These estimations provide more reliable estimates of the effect of fiscal rules on government bond yields, with the caveat that our IV may underestimate this effect.

Taken together, our baseline empirical tests suggest a significantly negative relationship between BBRs and government financing costs measured by state government bond spreads.

The impact of BBR on bond spreads with different maturities. We proceed to study whether there are differential impacts of BBRs on bond spreads with different maturities. We test for this potential heterogeneity by adding an interaction term "BBR $\times$ Short", where "Short" is a dummy variable that denotes short-term bonds with a maturity ≤ 1 year or ≤ 2 years, together with the dummy variable "Short" itself. We consider all the control variables including the debt-to-GDP ratio, GDP growth, bond characteristics, other fiscal controls, and fixed effects. Table 5 reports the result of this exercise across various specifications. The coefficient on BBR remains significantly negative in all of the specifications. The coefficients on the interaction term are all estimated to be positive, with the ones in two-way fixed effects models being significantly positive regardless of which BBR measure we use and how we define "Short". This result implies that the spread of short-term bonds reacts much less aggressively to a change in BBR than that of longer-term ones.

Table 4: State Bond Spread and BBR

	Panel A: *OLS, No Deficit Carryover*				**Panel B**: *OLS, ACIR Index*				**Panel C**: *IV Estimation*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
BBR	-0.102*	-0.123**	-0.174**	-0.166**	-0.012	-0.014	-0.024*	-0.022*	-0.541*	-1.201**	-0.109	-0.211**
	(0.059)	(0.055)	(0.077)	(0.071)	(0.009)	(0.009)	(0.014)	(0.013)	(0.323)	(0.490)	(0.086)	(0.099)
Debt/GDP	1.642*	1.578*	3.607**	3.261**	1.649*	1.624**	3.582**	3.232**	2.142**	2.806	1.993	3.301*
	(0.830)	(0.788)	(1.480)	(1.380)	(0.842)	(0.805)	(1.546)	(1.446)	(1.032)	(2.084)	(1.309)	(1.957)
ΔGDP	-1.554	-1.613	0.015	-0.798	-1.505	-1.601	0.021	-0.796	-4.884**	-1.745	-5.489*	-2.061
	(1.633)	(1.634)	(1.614)	(1.738)	(1.671)	(1.683)	(1.642)	(1.777)	(2.385)	(2.318)	(2.834)	(2.779)
Maturity	0.074***	0.073***	0.067***	0.067***	0.075***	0.074***	0.068***	0.067***	0.064***	0.053***	0.064***	0.054***
	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)
Coupon	0.070**	0.076***	0.089***	0.091***	0.070**	0.075***	0.088***	0.091***	0.088**	0.110***	0.087**	0.105***
	(0.027)	(0.028)	(0.028)	(0.028)	(0.027)	(0.028)	(0.027)	(0.028)	(0.033)	(0.033)	(0.034)	(0.033)
Fiscal Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	No	No	No
State Fixed Effect	No	No	Yes	Yes	No	No	Yes	Yes	No	Yes	No	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.264*	0.054	0.035	0.146	0.284*	0.099	0.101	0.203	0.431*	0.876*	0.958	1.787*
	(0.155)	(0.219)	(0.204)	(0.487)	(0.165)	(0.230)	(0.212)	(0.478)	(0.253)	(0.524)	(0.730)	(1.009)
N	978	978	977	977	978	978	977	977	806	806	806	806
R^2	0.385	0.392	0.436	0.438	0.384	0.391	0.434	0.436	0.285	0.238	0.223	0.181

Notes: This table reports the baseline coefficient estimates of (3.1) and their standard errors (all clustered by state). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Panel A reports OLS estimation results using the deficit carryover definition of BBR. In the OLS estimation results shown in Panel B, BBR tightness is proxied for by the ACIR Index. Panel C shows results using state government surplus (measured by total revenue less total expenditure, in logs and with a two-year lag) as the instrumental variable. Columns (9) and (10) use the "No Deficit Carryover" measure of BBR; (11) and (12) use the "ACIR Index" measure. The control variables for state economic conditions (Debt/GDP, per-capita GDP growth ΔGDP) and fiscal conditions (ΔGDP, Revenue/GDP, and Expenditure/GDP) all enter the regressions with a one-year lag. We consider two fixed effects—the state fixed effect and the time fixed effect. "Yes" means that the corresponding group of variables and fixed effect are considered in the regression. R^2 are reported as adjusted R^2 for OLS results and overall R^2 for IV results.

Table 5: BBR and State Bond Spread: Long-Term v.s. Short-Term

	Panel A: *No Deficit Carryover*		**Panel B**: *ACIR Index*	
	(1)	(2)	(3)	(4)
BBR	-0.278***	-0.346***	-0.043**	-0.060***
	(0.100)	(0.119)	(0.017)	(0.021)
BBR × Short	0.202*	0.254*	0.037**	0.051**
	(0.106)	(0.127)	(0.016)	(0.022)
Short	-0.324***	-0.506***	-0.471***	-0.737***
	(0.100)	(0.140)	(0.145)	(0.209)
N	977	977	977	977
adj. R^2	0.448	0.453	0.447	0.453

Notes: This table reports the coefficient estimates and their standard errors (all clustered by state), adding an interaction term "BBR × Short" where "short" is a dummy variable that is 1 if the bond maturity is equal to or less than 1 year (columns 1 and 3) or 2 years (columns 2 and 4), and the dummy "Short" itself. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Panel A reports OLS estimation results using the deficit carryover definition of BBR. In the estimation results shown in Panel B, BBR tightness is proxied by the ACIR Index. As with other regressions, we control for bond characteristics including coupon and maturity and variables about state economic conditions (Debt/GDP, per-capita GDP growth ΔGDP) and fiscal conditions (Revenue/GDP, and Expenditure/GDP). Both state fixed effect and year fixed effect are considered.

3.3 Robustness Tests

Although our baseline estimation consistently demonstrates a negative correlation between BBRs and state bond spreads, there may still be concerns regarding the validity of this outcome. First, our newly constructed measures of BBR may not capture all the requirements underlying a BBR, given the complexity of BBR implementation in practice. Second, there may be omitted factors that systematically affect both fiscal rules and state bond spreads, leading to biased estimates. To address these concerns, we conduct the following robustness tests.

Adding state political party information. To address the second concern, we include a possible omitted factor that might simultaneously drive a state government's preference for fiscal rules and financial outcomes. In particular, we include political factors besides the aforementioned baseline explanatory variables. We take our data from the National Conference of State Legislatures. States are classified as "Democratic" if both legislative chambers have Democratic majorities, while "Republican" indicates that both legislative chambers have Republican majorities. A state is "Split" if neither party has majorities in both legislative chambers. Following this classification, we construct two dummy variables, "Democratic" and "Republican", and include them as additional explanatory variables. The first panel of Table B.2 shows that controlling for these variables has minimal impact on our baseline results. Furthermore, the coefficients of these political party variables are not significantly different from 0, indicating that political party control is not a key factor in explaining the variation in state government financing costs after controlling for BBR.

Adding dependency ratio. The difference in demographic structures across states may also be a confounding factor that biases our baseline result. Butler and Yi (2022) find that an increase in a state's population age leads to a significant increase in municipal bond issue spread via three channels: lower tax revenue, higher unfunded pension obligations, and higher retiree healthcare liabilities. Given that these changes may also facilitate changes in state government fiscal rules, population aging may likely be an omitted variable. Therefore, we add the state dependency ratio, measured by the ratio of the retirement age population (65+) to working age population (18-64), to the baseline regressions using an OLS approach. The second panel of Table B.2 presents the estimation result. The coefficient of BBR stays unchanged to this additional control variable, and the coefficient on "Dependency Ratio" is not significant.

Alternative measures of BBR. In addition to the two BBR measures described in the main text, we also estimate (3.1) using an alternative measure derived from the Urban Institute's definition[9], which classifies BBRs into five categories: "Governor must ultimately sign, no deficit carryover permitted", "Governor must ultimately sign, deficit carryover permitted", "Governor must propose or legislature pass, no deficit carryover permitted", "Governor must propose or legislature pass, deficit carryover permitted" and "none". Although the ranking of BBR tightness is not clear from this definition, it's certain that the first category is the strongest. Therefore, we define a dummy variable that is equal to 1 if a state belongs to the first category, and 0 otherwise. We perform the same exercise as in the baseline and present the result in the third panel of Table B.2. Across the two specifications (adding fiscal control variables or not), the coefficients on the BBR are consistently negative, in line with our baseline results. In our most preferred specification with fiscal control variables and two-way fixed effects, this coefficient is significantly different from 0 at the 10% level. In terms of magnitude, the estimated BBR coefficient is similar to that

[9] https://www.urban.org/research/publication/balanced-budget-requirements.

in the baseline regression using the "No Deficit Carryover" dummy variable as the explanatory variable, which lends more support to the robustness of our main conclusion.

We also include the "no deficit carryover" restriction and the legal requirements as separate time-varying regressors. We consider two primary legal requirements on a balanced budget: "the legislature must pass a balanced budget" and "the BBR is constitutional." Table B.3 shows that investors are primarily concerned about deficit carryover restrictions, our main measure of BBR in the baseline regressions. And the coefficient estimates on this dummy variable are almost unchanged compared with Panel A of Table 4. We do not find evidence that legislative characteristics of this rule would affect market perception of risk.

Rainy day funds. Rainy day funds, or budget stabilization funds, can be used by the state government with unexpected deficits. The size of this fund, therefore, could matter for government spreads along with the BBR. To investigate how it would affect our main result, we collect the rainy day fund data for each state during the years 1984–2020 and include it as an alternative or additional regressor to BBR. The results are presented in Table B.5. The main takeaway from this table is that accounting for rainy day funds does not change the conclusion drawn from our baseline exercise—the BBR coefficients remain significantly negative in all of our specifications. For the impact of rainy day funds on state bond spreads, it is significantly negative when only year fixed effect is included.

3.4 Inspecting the Mechanism

Schwert (2017) shows that the tax-adjusted municipal bond yield spread can be decomposed into a default risk component, and an illiquidity compensation component. In this section, we proceed to understand the channels through which a BBR affects government borrowing costs and highlight the role of sovereign default risk. To understand the correlation between BBRs and default risk, we use state government CDS spreads (premia) to measure the default component of state bond spreads. CDS data are readily available from Bloomberg, and they provide a direct measure of state government credit default risk as perceived by investors. They are available for 19 states from 2010 to 2020, and 10 states for 2009.[10] To increase the sample size used in estimation, we impute BBR data for 2009 by assuming that all state BBRs remained unchanged

[10] CDS only exists for a subset of state issuers and did not trade prior to 2008. States that have CDS data are California, Connecticut, Delaware, Florida, Illinois, Maryland, Michigan, Minnesota, Nevada, New Jersey, New York, North Carolina, Ohio, Rhode Island, South Carolina, Texas, Utah, Washington, and Wisconsin.

Table 6: CDS Spreads and BBRs

	2009, 2014 and 2020		*2014*		*2014 and 2020*	
	(1)	(2)	(3)	(4)	(5)	(6)
BBR	-0.434**	-0.072**	-0.400**	-0.066**	-0.344*	-0.056*
	(0.170)	(0.029)	(0.170)	(0.029)	(0.195)	(0.033)
Debt and GDP	Yes	Yes	Yes	Yes	Yes	Yes
Other Fiscal Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	48	48	19	19	38	38
adj. R^2	0.344	0.341	0.223	0.204	0.137	0.132

Notes: This table reports the coefficient estimates and their standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Effective sample period: 2009, 2014, and 2020 for (1) and (2); 2014 for (3) and (4); 2014 and 2020 for (5) and (6). BBR takes the "No Deficit Carryover" dummy variable in (1)(3)(5), and the "ACIR Index" in (2)(4)(6). All specifications include debt-to-GDP ratio, GDP growth, revenue-to-GDP ratio and expenditure-to-GDP ratio as control variables. The estimations are pooled OLS regressions of all observations. CDS data source: Bloomberg.

from 2007, the closest year to 2009 with available BBR data. This allows us to run a pooled OLS regression using 48 observations.[11] To address potential concerns of this imputation, we also show results excluding data for 2009. In addition, 2020 was the first year of COVID-19 pandemic, which might be special for various reasons. We therefore also present result using 2014 data only.

Table 6 presents the coefficient estimates of BBR as well as their standard errors, controlling for debt, GDP and other fiscal variables. We find that BBR existence is negatively correlated with CDS premia in all of our samples, regardless of the measure for BBR. It is evident that coefficients on BBR for both measures are significantly negative at the 10% level (at least). This result implies that other things being equal, imposing a BBR (columns 1, 3, and 5) or more stringent BBR (columns 2, 4 and 6) would lead to a significantly lower government default risk, and thus lower borrowing costs for state governments. In Appendix B Table B.6, we present robustness of this result using alternative specifications and robust standard errors.

These results suggest the crucial role played by the default risk channel in explaining the negative correlation between BBR and state government bond spreads, which motivates a sovereign default model in quantifying the impact of BBRs.

[11] Panel regressions controlling for fixed effects are not feasible because of the small sample size.

4 Model

Our empirical results show that states with tighter BBRs are associated with significantly lower state government spreads, and that default risk is a plausible explanation for this finding. In this section, we employ a sovereign default model to elucidate the mechanism and facilitate further quantitative analysis. The main departures from a standard sovereign default model à la Arellano (2008) are as follows. First, we impose a BBR for the government and explore the implications of implementing a BBR for government financing. Second, we incorporate capital into the model, which is similar to Gordon and Guerron-Quintana (2018). This addition enables us to examine the broader impacts of BBRs on investment and future output together with the spreads. In Section 5.5, we also add the federal government, which acts as a fiscal stabilizer by providing transfers to state governments during times of economic distress.

4.1 Model Environment

The economy is populated by a large number of identical households and a benevolent state government. The state government borrows in the financial markets to maximize the utility of the households. The government has access to a technology that uses capital K_t and hires labor L_t to produce output y_t using the production function $y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$. We assume that productivity A_t follows a first-order autoregressive process: $\log(A_t) = \rho \log(A_{t-1}) + \varepsilon_t$, where ε_t follows a normal distribution with mean zero and a standard deviation σ_A.

Households provide labor L_t inelastically and earn wage income $w_t L_t$. They have a discount factor β and a constant relative risk aversion utility function over consumption c_t given by: $u(c_t) = c_t^{1-\sigma}/(1-\sigma)$, where σ is the risk aversion parameter. Households pay income tax at a rate of τ and receive lump-sum transfer T_t from the state government.

The government borrows from risk-neutral lenders by issuing long-term state-uncontingent bonds to external risk-neutral lenders. At the beginning of each period, a fraction ϕ of government debt matures, with the remaining $1-\phi$ staying outstanding. Bond price q_t is determined endogenously and reflects the government default risk. If the government defaults, the economy suffers a productivity loss: $A_d = h(A) \leq A$. In the quantitative part, we specify $h(A) = \min\{A, \gamma \mathbb{E}A\}$, where γ is a parameter that governs the productivity loss, and $\mathbb{E}A$ is the expected value of the productivity process, following Arellano (2008). Under this specification, if productivity is higher than the threshold $\gamma \mathbb{E}A$, then $h(A) = \gamma \mathbb{E}A$. Otherwise, $h(A) = A$. This formula of asymmetric default costs makes the value of autarky less sensitive to the shock and is commonly used in the literature. Once defaulting, the government is excluded from the credit market but regains the ability to borrow with probability λ.

The government also makes capital investment decisions. We assume that capital depreciates at a rate δ and there is an adjustment cost for changing the capital stock. Investment in capital is given by $i_t = K_{t+1} - (1-\delta)K_t + \Theta(K_{t+1}, K_t)$, where $\Theta(K_{t+1}, K_t) = \frac{\theta}{2}(\frac{K_{t+1}}{K_t} - 1 + \delta)^2 K_t$ is the convex adjustment cost for capital. We assume that capital cannot be expropriated in default, so the government can still decide how much to invest at the default state. The government rebates profit to the households each period in the form of transfers, that is, $T_t = A_t K_t^{\alpha} L_t^{1-\alpha} - w_t L_t$.

4.2 Recursive Formulation

We first describe the government's problem under no BBR with a recursive formulation and characterize the recursive equilibrium. We omit the time subscript t to simplify the notation and use x' to denote the variable x in the next period. The timing of the model is as follows. At the beginning of a period, the government observes the realization of productivity shock A, the capital stock level K, and the debt level B. The government then decides on whether to default on its debt and how much to invest. If the government repays its debt, it can choose a new debt level B' where the new debt issuance is $B' - (1-\phi)B$. If the government defaults, it enters a state of financial autarky but with probability λ of returning to the financial market.

A government with access to financial markets chooses whether to default on its debt by comparing the repayment value and the default value:

$$V(A, K, B) = \max\{V^c(A, K, B), V^d(A, K)\}, \tag{4.2}$$

where V^c and V^d denote the non-defaulting and defaulting values respectively. When the defaulting value is larger, the government chooses to default on its debt, denoted by $D(A, K, B) = 1$. If the government does not default, it chooses the new debt level B' and new capital level K' to solve the following dynamic programming problem:

$$V^c(A, K, B) = \max_{\{c, K', B'\}} \quad u(c) + \beta \mathbb{E}\left[V(A', K', B')\right], \tag{4.3}$$

subject to the household budget constraint, government budget constraint, and law of motion for capital:

$$c = (1 - \tau)wL + T, \quad c \geq 0, \tag{4.4}$$

$$i + \phi B = \tau wL + Q(A, K', B')\big(B' - (1 - \phi)B\big), \tag{4.5}$$

$$i = K' - (1 - \delta)K + \frac{\theta}{2}\left(\frac{K'}{K} - 1 + \delta\right)^2 K, \tag{4.6}$$

where ϕB is the debt repayment, τwL is the income tax revenue, $Q(A, K', B')$ is the bond price, and $Q(A, K', B')\big(B' - (1 - \phi)B\big)$ is the proceed from new debt issuance. Combining (4.4) and (4.5), we could derive the economy-wide resource constraint:

$$c + i + \phi B = AK^{\alpha}L^{1-\alpha} + Q(A, K', B')\left(B' - (1 - \phi)B\right) \tag{4.7}$$

If the government defaults, the debt is extinguished. However, the local economy experiences a productivity loss from A to A_d and the government enters financial autarky. In financial autarky, the government is unable to issue bonds. With probability λ, the government returns to the financial market with no initial debt. The default value is then given by:

$$V^d(A, K) = \max_{\{c, K'\}} \quad u(c) + \beta \mathbb{E}\left[\lambda V(A', K', 0) + (1 - \lambda)V^d(A', K')\right], \tag{4.8}$$

subject to the economy-wide resource constraint when default:

$$c + i = A_d K^{\alpha} L^{1-\alpha}, \tag{4.9}$$

where A_d is the productivity during financial autarky.

We assume a competitive lending market in which lenders are risk neutral. They face a constant world risk-free interest rate r^* and are willing to lend to the government as long as they break even in expected value. Moreover, lenders are aware of the government's incentives to default on its bonds. Thus, in equilibrium, the bond price schedule $Q(A, K', B')$ satisfies:

$$Q(A, K', B') = \frac{1}{1 + r^*}\mathbb{E}\left[(1 - D(A', K', B'))(\phi + (1 - \phi)Q(A', K'', B''))\right], \tag{4.10}$$

where $K'' = K'(A', K', B')$ and $B'' = B'(A', K', B')$. The bond price compensates the lenders for their losses in case of a sovereign default. If the government defaults, i.e. $D(A', K', B') = 1$, the lenders receive nothing. If the government repays, i.e. $D(A', K', B') = 0$, the lenders receive the fraction ϕ of debt that has matured and the market value of the remaining $1-\phi$ that has not. The bond price captures the entire future path of probability of default through its dependence on $Q(A', K'', B'')$. The government spread on its bond is defined as $spread(A, K', B') = \phi/Q(A, K', B') - (\phi + r^*)$.

To gain some intuition on the government's problem, it's important to recognize that governments have three instruments to influence the path of consumption: default, borrowing, and investment. When a government chooses to default, it is essentially prioritizing current consumption at the expense of being excluded from the financial markets and of incurring output losses. Default may be a preferred strategy to escape a situation where high levels of debt and low levels of technology would otherwise lead to significantly reduced consumption. When the government has access to the financial market, it can choose how much to borrow. Borrowing serves as an instrument to shift consumption towards the present, the standard mechanism of consumption smoothing. The third instrument available to the government is capital investment. Capital investment increases future output and thus provides higher consumption for tomorrow. Therefore, capital serves as another way for saving and borrowing, but it is resilient to default risk. When combined with borrowing from financial markets, the government can increase its investment during periods of higher productivity and more favorable borrowing conditions. Fiscal policies such as BBRs can influence these government decisions, subsequently affecting the bond prices faced by the government. We will delve into this impact in the next subsection.

4.3 Government Financing with a BBR

In this section, we analyze the government's problem when there is a BBR. As illustrated in the empirical section, BBRs vary in their stringency and forms across governments. Following Azzimonti et al. (2016), it is modeled as a constitutional requirement related to the cost of servicing the debt. Specifically, we model a BBR as a requirement that when the government makes a borrowing decision B', it must consider its associated impact on the government balance sheet: interest payment and government spending must be sufficiently covered by government revenues. Formally, in our context, given the aggregate state variables $S = (A, K, B)$, a BBR requires that the government tax revenue is larger than or equal to the sum of government spending and interest payment on debt:

$$\tau w L \geq i + \phi B' - Q\left(A, K', B'\right)\phi B', \tag{4.11}$$

where τwL is the tax revenue, i is the government investment, and $\phi B' - Q(A, K', B')\phi B'$ is the interest payment on debt that are determined in the current period.[12] Combined with the government budget constraint (4.5), the BBR constraint (4.11) is equivalent to the following constraint that determines the debt level that government is allowed to take:

$$\phi B - Q(A, K', B')\left(B' - (1-\phi)B\right) \geq \phi B' - Q\left(A, K', B'\right)\phi B', \tag{4.12}$$

which shows that a BBR imposes an additional constraint on government borrowing besides the endogenous borrowing constraint implied by government default risk, and that feasible debt levels for the next period are contingent on the debt level in the current period. This constraint can be reduced to a simple form: $B' \leq B$. That is, the debt level cannot increase, identical to the one derived in Azzimonti et al. (2016).[13]

Figure 3 provides a graphical illustration of how a BBR serves as an additional constraint. The black and red curves illustrates how next-period debt changes with current debt without and with the BBR. When current debt is low, the BBR constraint is binding: optimal B' without a BBR is larger than current debt B. When current debt is high, BBR no longer binds. This distinction will play a role in our discussion of impact of BBRs at different levels of existing debt. It's worth noting that Figure 3 illustrates the BBR constraint at a fixed interest rate, while in our model, the bond price is endogenous. We plot the actual debt policy functions using our calibrated model in the quantitative section.

We now turn to government's problem with a BBR. Under a BBR, the government still maximizes household utility by choosing whether to default on its debt or not. If the government chooses to repay, it can choose a new level of debt, B', by solving a similar dynamic programming problem (4.3) but with the BBR as an additional constraint. Specifically, the repayment value for the government is now given by:

$$V^c(A, K, B) = \max_{\{c, K', B'\}} \quad u(c) + \beta \mathbb{E}\left[V(A', K', B')\right], \tag{4.13}$$

[12] We thank an anonymous referee for initiating the following derivation. Interest expense is defined as the cost of maintaining the debt level at current prices, which is $r(A, K', B')\, Q(A, K', B')\, B'$, which can be further derived as follows:

$$r\left(A, K', B'\right) Q\left(A, K', B'\right) B' = \left(\frac{\phi}{Q\left(A, K', B'\right)} - \phi\right) Q\left(A, K', B'\right) B' = \phi B' - Q\left(A, K', B'\right)\phi B'$$

[13] One could relax the stringency of a BBR by assuming a reduced form constraint $B' \leq \chi B$, where χ is a parameter that governs the stringency of a BBR. A larger χ implies a less stringent BBR.

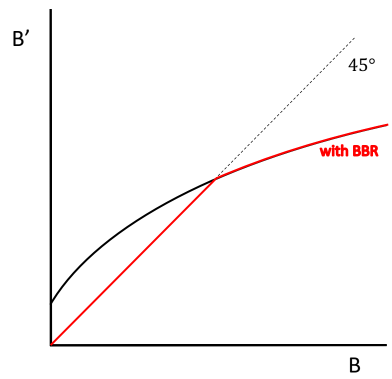


Figure 3: Graphical Illustration of a BBR

Notes: A BBR imposes a constraint on government borrowing. This figure provides a graphical illustration on the impact of a BBR. The black curve plots how next period's debt evolves with the current debt level without the BBR. When a BBR is added (the red curve), next-period debt can not exceed the 45 degree line.

subject to the resource constraint (4.7), law of motion for capital (4.6), and the BBR (4.11).

If the government chooses to default, the optimization problem is the same as before because the budget constraint under default already trivially satisfies the BBR.

Recursive equilibrium. The recursive equilibrium consists of policy functions for consumption $c(A,K,B)$, transfers $T(A,K,B)$, debt borrowing $B'(A,K,B)$, investment $i(A,K,B)$, default set $D(A,K,B)$; government value functions $V(A,K,B)$, $V^c(A,K,B)$, and $V^d(A,K)$; and the government bond price $Q(A,K',B')$ such that:

1. Taking the government policies as given, household consumption $c(A,K,B)$ satisfies the resource constraint (4.7) or (4.9).

2. Taking the bond price schedule $Q(A,K',B')$ as given, the government's choices for borrowing $B'(A,K,B)$, investment $i(A,K,B)$, and its default set $D(A,K,B)$, along with its value functions $V(A,K,B)$, $V^c(A,K,B)$, and $V^d(A,K)$, solve the government problem (4.2), where the repayment value $V^c(A,K,B)$ is given by (4.13) and the default value $V^d(A,K)$ is given by (4.8).

3. Bond price schedule (4.10) reflects the probability of government default and satisfies lenders' break-even condition.

5 Quantitative Analysis

5.1 Parameterization

We parameterize the model with no BBR using data from the state of Illinois. We choose Illinois because it's a state that has consistently experienced financial difficulties that have only worsened since the pandemic. Based on the state's 2020 audited financial reports, Illinois had a "taxpayer burden" of $57,000, earning it an "F" grade from Truth in Accounting.[14] The CDS spread for Illinois is also higher than for other states: Between 2009 and 2020, Illinois had an average CDS spread of 237 bps, while the average for all other states was 67 bps; in 2020, it reached 327 bps, much higher than many other states. A high spread means that when issuing bonds the government has to offer a higher interest rate, which increases debt service costs and makes it harder for the government to roll over debt. If imposing a BBR can lower bond spreads for newly issued bonds, it could help Illinois' finances and ultimately its taxpayers.

The model is calibrated at an annual frequency. We parameterize the model to match key moments of the Illinois data from 2009 to 2020. There are two groups of parameters. The first group is assigned following the standard literature or estimated outside the model, and those in the second group are jointly estimated to match relevant empirical moments. The first group includes $\{\alpha, \delta, r^*, \sigma, \phi, \lambda, \tau, \rho\}$. The capital share α is set to 0.33, the capital depreciation rate δ is set to 0.1, the annual risk-free rate r^* is set to 2%, and the risk aversion parameter σ is set to 2, all of which are standard values. As we are using 5-year CDS spread data, the fraction of long-term debt that needs to be repaid each period ϕ is 0.2. Following Gelos et al. (2011), the return parameter λ is set to be 0.25 such that a defaulting government is excluded from financial markets for four years on average.[15] Tax revenue is about 5.2% of total state GDP for Illinois in the data, which gives the value of τ in this model. We follow Neumeyer and Perri (2005) and set the persistence of the productivity process ρ to be 0.95.

The second group is $\{\beta, \gamma, \sigma_A, \theta\}$, where β is the discount factor, γ is the parameter in the productivity loss function when in default, σ_A is the volatility of the productivity process, and θ is the capital adjustment cost parameter. We choose these parameters to jointly target Illinois'

[14] https://www.data-z.org/state_data_and_comparisons/detail/illinois

[15] State government default triggers financial exclusions. For example, after Arkansas defaulted in 1933, large financial centers remained closed to Arkansas for some time. In New York and Pennsylvania, the banks and trusts could not invest in Arkansas bonds until 1944 and not until 1954 for investors in Massachusetts and Connecticut. However, because there is not enough data on the length of exclusion, we adopt a standard value in the literature.

Table 7: Parameters

Parameter	Description	Value	Target/Source
α	Capital share	0.33	Conventional value
δ	Depreciation rate	0.1	Conventional value
r^*	Risk-free rate	2%	Conventional value
σ	Risk aversion	2	Conventional value
ϕ	Fraction of bonds maturing	0.2	5-year bond maturity
λ	Return parameter	0.25	Gelos et al. (2011)
τ	Tax rate	0.078	Tax revenue/state GDP
ρ	Persistence of productivity process	0.95	Neumeyer and Perri (2005)
β	Discount factor	0.9	Debt-to-GDP ratio
γ	Loss function parameter	0.97	Mean of spread
σ_A	Volatility of productivity process	0.0037	Volatility of GDP
θ	Capital adjustment cost	4	Relative volatility of investment

average spread (2.37%), average debt-to-GDP ratio (0.084), volatility of GDP (0.018), and the relative volatility of investment (3.72).[16]

We solve the model numerically using value function iteration and interpolation. Appendix C.1 details the computational methods. Given the policy functions, we perform simulations to obtain the model-implied counterparts of our targets. We jointly estimate the parameters to match the sample moments by minimizing the sum of the distance between the moments in the model and their corresponding counterparts in the data. Table 7 reports all of our calibrated and estimated parameters used in the following quantitative exercise.

5.2 Impacts of a BBR

We first present the bond pricing schedules in the absence of a BBR. Figure 4 plots the government bond price and the corresponding bond spreads as functions of debt, at different levels of productivity and capital. A lower bond price q indicates that the government obtains less funding for a given repayment, thus is associated with higher financing cost measured by the bond spread. As existing debt position rises, bond prices decrease and spreads increase because of

[16]Both GDP and investment are in logs and detrended. For the relative volatility of investment, we use data at the US aggregate level because state-level capital and investment data are not available from BEA, and in the literature, there is no reliable method for estimating state-level capital. The few papers that have attempted to estimate it have made very strong assumptions, which limits the reliability of their results. To avoid these issues, we decided to use aggregate investment data as a proxy.

higher default risk.

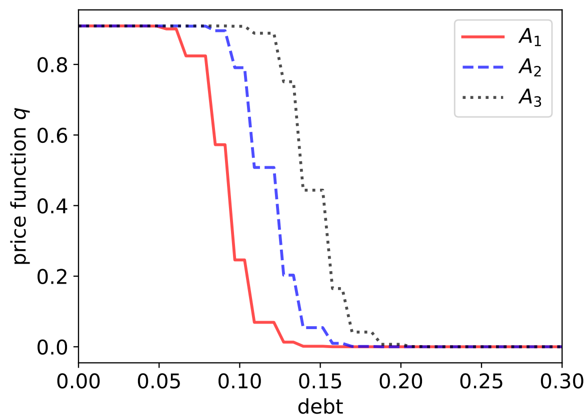
Panel (a) and (b) plot the bond price and spread schedules at different productivity levels. With lower productivity, the bond price is lower and spread is higher. The reason is that persistently lower productivity leads to reduced government revenue, which in turn raises the risk of default.

Panel (c) and (d) plot the bond price and spread schedules at different levels of capital. The impact of capital on government default risk has two counteracting forces, as shown in Gordon and Guerron-Quintana (2018). First, the government can use capital to insure themselves intertemporally and take advantage of high productivity and favorable borrowing conditions by increasing investment, which lowers default risk in the future. Second, as the economy's capital stock increases, so does the value of default: more capital increases the value of being in financial autarky. Quantitatively, consistent with Gordon and Guerron-Quintana (2018), we find that the first force dominates—a higher capital stock lowers default risk and bond spreads.

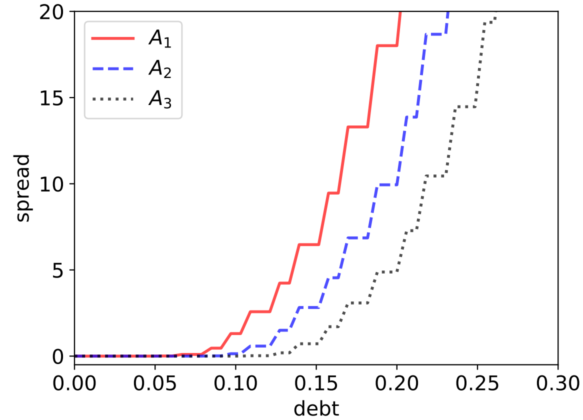
Combining the findings in the four panels, it becomes apparent that bond prices and spreads are tightly linked to debt, productivity, and capital levels. This provides a theoretical foundation for incorporating debt and GDP as crucial control variables in our empirical specifications.

Next, we compare government bond price, spreads, and the policy functions for the next-period debt and capital with and without a BBR in Figure 5. Panel (a) and (b) plot the bond price and spread as functions of current debt level fixing productivity and capital at their median levels. The solid blue lines plot the scenario without a BBR and the dashed black lines plot the case with a BBR. As debt increases, bond price decreases and spread increases. Moreover, given the level of productivity and capital, the bond price is significantly higher and spread significantly lower when a BBR is in place. This is because the lenders are aware that a BBR will constrain the government's borrowing and future default risk.

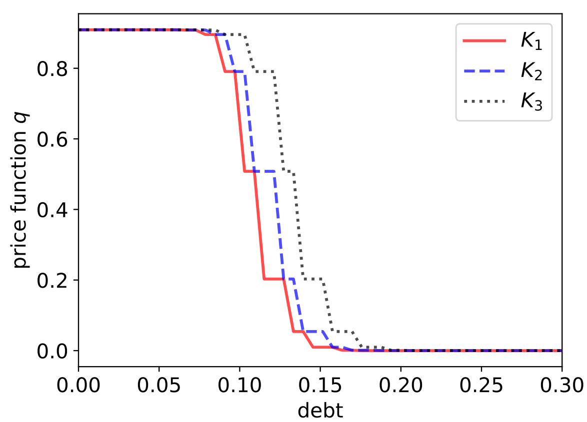
Panel (c) plots the difference between the spreads without and with a BBR, reflecting the reduction in spreads that a BBR can bring about, against the debt level. Given the productivity level, the spread gap rises with the amount of debt, suggesting that BBRs are more effective in reducing debt spreads when the government is more indebted. The solid red and dotted black lines plot the spread gap for a low and high productivity level, respectively. We find that the impact of a BBR is greater at a lower level of productivity given current debt level. Panel (d) plots the spread gap under different capital levels. Similarly, the spread gap increases with the amount of debt given the capital level and the impact of a BBR is greater for an economy with a lower



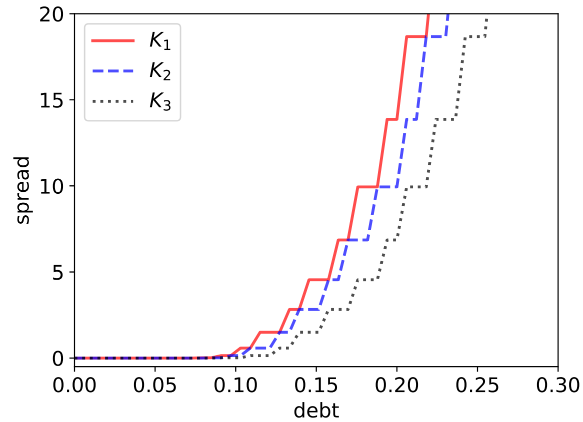
(a) Price function (different productivity)



(b) Spreads (different productivity)



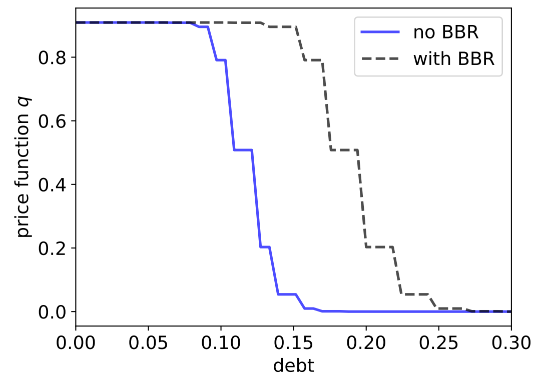
(c) Price function (different capital)



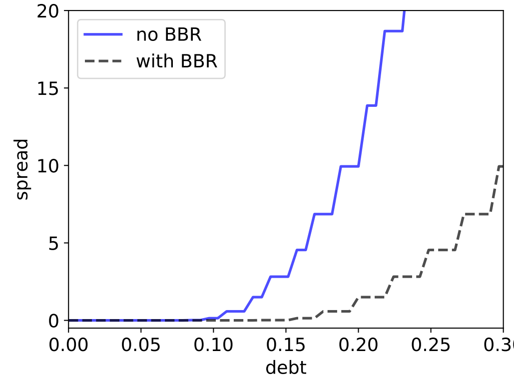
(d) Spreads (different capital)

Figure 4: Bond Prices and Spreads

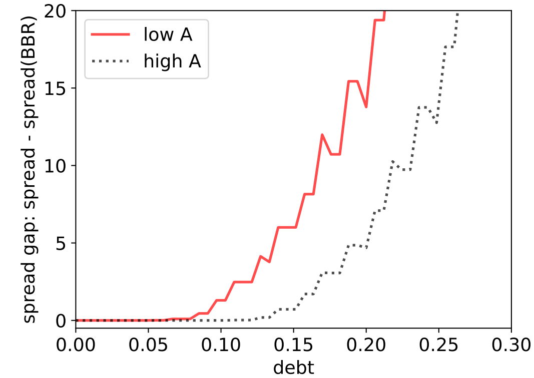
Notes: This figure plots bond prices and spreads as functions of total debt under different productivity levels $A_1 < A_2 < A_3$ or different capital levels $K_1 < K_2 < K_3$, where A_2 and K_2 are the median levels of the simulated productivity and capital, respectively. The x-axis is the debt level. The y-axis is bond price in Panel (a)(c) and bond spread in Panel (b)(d).



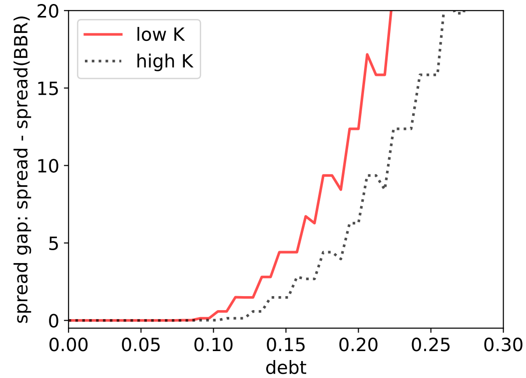
(a) Price function



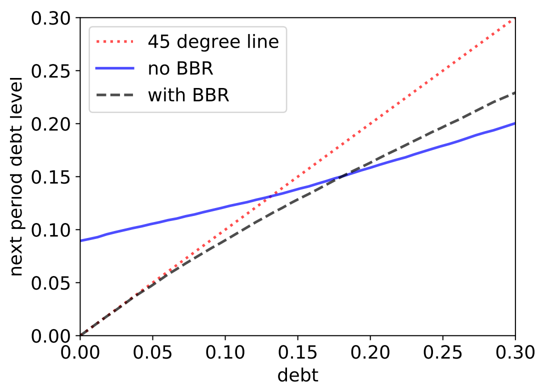
(b) Spreads



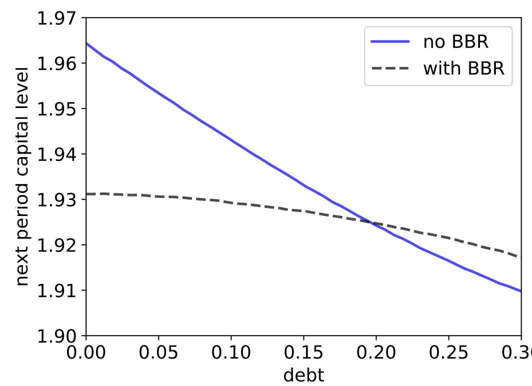
(c) Spread gap under different productivity



(d) Spread gap under different capital



(e) Next-period debt



(f) Next-period capital

Figure 5: Bond Spreads and Policy Functions: Impacts of a BBR

Notes: Panel (a) and (b) plot bond prices and spreads as a function of debt with and without a BBR fixing productivity and capital at their median levels. Panels (c) and (d) plot the gap between the spreads with and without a BBR as a function of debt at different productivity or capital levels. The 'low' and 'high' labels refer to productivity or capital relative to their median levels. When plotting Panel (c), capital is fixed at its median level; when plotting Panel (d), productivity is fixed at its median level. Panel (e) and (f) plot the average decision rules for next period's debt and capital as functions of current debt.

level of capital. These two observations lead to clear implications for the timing of imposing BBRs: BBRs are more effective in reducing spreads when the economy is more indebted or in a recession.

Panel (e) depicts the average decision rule for next-period debt as a function of existing debt with a BBR (dashed black) and without a BBR (solid blue). When debt levels are relatively low, governments borrow less under a BBR. This is because a BBR restricts the amount of debt that governments are allowed to take on. However, as the existing debt levels rise, debt levels in the next period can be lower in the absence of a BBR. This counterintuitive result arises from the high risk associated with high levels of debt. Lenders, recognizing this risk, will demand a higher interest rate to compensate for the increased possibility of nonpayment. As a result, governments are forced to reduce their borrowing, resulting in lower next-period debt levels even in the absence of the restrictions imposed by a BBR. This feature distinguishes our framework from existing public debt models without default risk where imposing fiscal rules such as the BBR would lead to lower future debt for all possible current debt levels. In Appendix C.2, we present explicit results on this comparison and emphasize the importance of allowing for default in such models.

Panel (f) illustrates the relationship between next-period capital and existing debt. As expected, capital investment declines as existing debt levels rise, suggesting that high levels of government debt can depress investment. When debt levels are low, capital investment tends to be higher without a BBR. This is because governments without a BBR have more flexibility to borrow and invest, which leads to higher capital investment. However, as debt levels rise, borrowing costs increase, particularly in the absence of a fiscal rule. The tighter resource constraint then leads to lower investment, especially so without a BBR.

5.3 Regression using Simulated Data

To investigate whether our model can generate a similar relationship between spreads and the implementation of a BBR as is shown in the data, we conduct regression analysis using the model-simulated data. We simulate the model without a BBR over a long period, and then introduce a BBR. Specifically, we simulate 3,000 paths for 300 periods, and drop the first 100 periods to eliminate the influence of the arbitrary (but reasonable) choice of initial guesses. We then average all relevant variables across the paths. The final sample comprises 100 periods before implementing a BBR and 100 periods after.

Table 8: Regression Results using Model-Simulated Data

	(1)	(2)	(3)	(4)	(5)	(6)
BBR	-1.943***	-1.797***	-1.798***	-1.986***	-1.896***	-1.897***
	(0.011)	(0.012)	(0.012)	(0.011)	(0.026)	(0.026)
Debt and GDP	No	Yes	Yes	No	Yes	Yes
Other Fiscal Controls	No	No	Yes	No	No	Yes
N	200	199	199	200	199	199
adj. R^2	0.994	0.997	0.997	0.994	0.997	0.997

Notes: This table reports the regression results and their robust standard errors (in parentheses) using model-simulated data. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Columns (1)–(3) utilize the complete simulated sample, whereas Columns (4)–(6) exclude observations in default prior to computing the average across simulations. Columns (1) and (4) do not include any controls. Columns (2) and (4) include debt-to-GDP and GDP growth as control variables. Columns (3) and (6) further control for revenue-to-GDP and spending-to-GDP.

We use the simulated data to study the impact of imposing a BBR on the government borrowing cost. Specifically, we conduct a regression analysis with spreads as the dependent variable and a dummy variable indicating the existence of a BBR as the independent variable. We also control for other factors such as debt, GDP, tax revenue, and government spending, as we did in the empirical analysis.

Table 8 presents the regression results using simulated data from the model. Columns (1)–(3) use the simulated sample computed using the average of all 3000 paths, while columns (4)–(6) exclude observations in a default state before computing this average. Columns (1) and (4) do not include any controls, while columns (2) and (4) include the debt-to-GDP ratio and GDP growth as control variables. Columns (3) and (6) add the revenue-to-GDP and spending-to-GDP ratios as additional control variables like we did in the baseline empirical specification. Across all specifications, the coefficients associated with BBR are consistently negative. This indicates that the implementation of a BBR is consistently associated with lower government spreads, which is consistent with our empirical findings.

5.4 The Dynamics of Government Finances Upon Imposing a BBR

What would happen if a BBR were imposed in the state of Illinois? To assess the dynamic impact of a BBR on government financing in Illinois, we simulate the model without a BBR before introducing one in year 1. We predict the changes in key government balance sheet variables and debt spreads by averaging across 3,000 paths of 500 periods each, after dropping the initial 100 periods.

Table 9 shows the predicted government spreads, debt, interest burden, and change in welfare in consumption-equivalent terms after a BBR is implemented in year 1. The debt spread plummets on impact from 2.345% to 0.618%, as investors anticipate lower debt levels and interest payments in the future, which leads to a lower default risk. After year 1, debt spreads continue to decline, but at a more gradual pace. Ten years after imposing a BBR, the government spread remains at a low level of 0.345%.

Government debt consistently declines after the policy change. One year after the change, the debt-to-GDP ratio falls considerably from 9.221% to 7.684%, and the debt-to-tax-revenue ratio falls from 176.437% to 147.025%. These ratios continue to decline throughout the simulation period. Due to lower debt and spreads, government debt burden—measured by interest payments—also falls substantially, by approximately two-thirds within 10 years.

Immediately after imposing a BBR, welfare in consumption-equivalent terms decreases by 0.5%. This is because a BBR constrains the government's ability to borrow, which can have a negative impact on government investment and household consumption. However, this welfare decrease is only temporary: starting from year 2, we begin to observe welfare improvements every year. This improvement in social welfare is driven by the improved government fiscal conditions characterized by lower borrowing costs and debt burdens. In the longer run, there can be welfare gains relative to the initial period.

Taken together, our quantitative analysis suggests that implementing a BBR could significantly lower the borrowing cost and improve the government balance sheet. However, the policy could have a negative impact on social welfare in the short run, as it would limit the government's ability to borrow. In the medium run, welfare gradually improves, and in the long run, the policy could generate welfare gains, as it leads to lower borrowing costs and debt burdens, which frees up resources for consumption and investment activities.

5.5 Accounting for Federal Government Transfers

Intergovernmental transfers, particularly those from the federal government, make up a significant portion of state government revenue. If these transfers are systematically affected by local economic conditions, they may have quantitative implications for our findings in previous analyses. We empirically investigate this potential interaction between the local economy and federal government transfers and determine whether it affects our baseline analysis.

The empirical challenge in estimating the relationship between state-level GDP and federal

Table 9: Predicted Government Finances After Imposing a BBR

Year	Government Spread(%)	Debt/GDP(%)	Debt/Tax revenue(%)	Interest payment/GDP (%)	Percentage change of welfare (%)
0	2.345	9.236	176.741	0.157	0.000
1	0.618	9.221	176.437	0.128	-0.499
2	0.454	7.684	147.025	0.104	0.066
3	0.310	6.442	123.263	0.089	0.083
4	0.283	5.450	104.286	0.077	0.082
5	0.294	4.644	88.861	0.069	0.063
6	0.347	4.030	77.122	0.062	0.058
7	0.354	3.545	67.830	0.055	0.037
8	0.293	3.152	60.315	0.052	0.034
9	0.317	2.839	54.325	0.049	0.022
10	0.345	2.615	50.047	0.048	0.023

Notes: This table reports predicted government spreads, debt ratios, interest payment and changes in welfare after a BBR is imposed in Year 1. Percentage change of welfare refers to year-over-year changes in total social welfare measured using consumption-equivalent terms.

transfers is that both variables are potentially non-stationary or even cointegrated. A standard least squares regression among these two will lead to spurious results. We first perform a panel data error-correction cointegration test based on Westerlund (2007), assuming a constant and deterministic time trend in each state. Our result strongly rejects the null hypothesis that the series are not cointegrated. We then estimate a panel error-correction model with homogeneous effects across panels specified as follows:

$$\Delta \log H_{it} = \psi_H^{ec} \log H_{i,t-1} + \psi_Y^{ec} \log Y_{i,t-1} + \psi_Y \Delta \log Y_{it} + \psi_{H1} \Delta \log H_{i,t-1} + \psi_{Y1} \Delta \log Y_{i,t-1} + \mu_i + kt + e_{it}, \tag{5.14}$$

where ψ_Y^{ec} and ψ_H^{ec} are the coefficients on the error correction terms, indicating the speed of adjustment towards the long-term equilibrium between the two cointegrated variables. In particular, if $\psi_H^{ec} < 0$, then there is error correction. The primary parameter of our interest is ψ_Y, which captures the short-term relationship between Y and H, that is, the change in intergovernmental transfers from the federal government when local GDP increases by 1%. Therefore, we expect ψ_Y to be negative.

Our least squares estimation of (5.14) gives a precisely estimated $\hat{\psi_H^{ec}} \approx -0.2$, again indicating strong cointegration of the two variables. In our baseline regression with time trend and lag GDP growth, $\hat{\psi}_Y$ is estimated to be around -0.1, with a standard error of 0.06. These results do not change much when we switch to alternative specifications. Details of this regression and alternative specifications are relegated to Appendix B.4.

Next, we allow federal government transfers to enter the state government budget constraint. The economy-wide resource constraint under repayment now becomes:

$$c + i + \phi B = AK^{\alpha}L^{1-\alpha} + Q(A, k', B')\big(B' - (1-\phi)B\big) + H, \tag{5.15}$$

where H is the federal government transfer. We assume a reduced-form transfer rule that depends on the economy's output, $H = (AK^{\alpha}L^{1-\alpha})^{\psi}$, where ψ is the elasticity of federal transfers with respect to state GDP. Based on our empirical estimation, we set ψ to be -0.1. A negative ψ captures the fact that intergovernmental transfers from the federal government are higher when the state is in a bad time. Due to the unavailability of sufficient data to estimate the transfer rule specifically for default episodes, we assume that an identical reduced-form transfer rule applies throughout. Therefore, when the state's productivity A falls to A_d as a result of default penalty, federal government transfers increase.

We solve the model incorporating federal transfers using the same method as before. The qualitative effects of a BBR remain consistent with our benchmark results: implementing a BBR leads to a decrease in government default risk and spreads. When comparing the policy functions for next-period debt and capital between scenarios with and without a BBR, we observe similar patterns to those displayed in Figure 5. We also simulate the model with federal transfers and conduct a regression analysis. The results show that the implementation of a BBR is associated with lower government spreads, consistent with the result from our benchmark model and the empirical findings, albeit the magnitude is slightly larger. As the results are almost identical to the previous analysis, we relegate these results from the extended model with a federal transfer rule to Appendix C.3.

6 Conclusion

In this paper, we study how public financing costs are affected by the BBR, which is often neglected in the literature on municipal bond prices, and in turn discuss its dynamic impacts on the government balance sheet. We use data on US state government bond spreads and a new dataset on state government BBRs to document that government spreads are negatively associated with the presence of and the tightness of BBRs. Our sovereign default model with a BBR can replicate these results, adding theoretical support to our empirical finding. Our model reveals that bond spreads as well as the impact of a BBR are jointly affected by productivity, capital, and debt levels. On the one hand, a BBR can reduce government spreads by imposing limitations on future government borrowing, thereby reducing bond spreads. On the other hand, a BBR could also impede investment due to a lack of available funding when government debt is not too high, subsequently leading to reduced future output and increased bond spreads. Quantitatively, we find that the first channel dominates, indicating that a BBR in equilibrium effectively reduces default risk and financing cost. This is a new angle on how BBRs can benefit the economy.

Moreover, we find that the difference in government spreads between a BBR and no BBR is larger when debt is higher and output is lower. This suggests that heavily-indebted and economically-hard economies tend to benefit more from a BBR. Using model-simulated data, we conduct regression analysis and show that the model generates a similar relationship between spreads and BBR as in the data. When calibrated to Illinois, our quantitative analysis shows that implementing a BBR would significantly lower the borrowing cost and improve the government balance sheet. In the long run, the policy could also generate welfare gains due to the improved fiscal discipline and lower debt burdens. In an extension of the model, we include federal government transfers and find that the results are consistent with the benchmark model.

Although we focus on US states in our analysis, our result are also relevant to the discussion of fiscal rules by national governments. In light of the heavy debt burdens facing many sovereigns in the past decade, our results suggest that imposing a BBR might be attractive to the extent that it can not only directly alleviate a government's fiscal burden, but also can indirectly improve its fiscal conditions via its impact on the cost of accessing the government bond market. In addition, cheaper borrowing costs may have other implications than is discussed in this paper. For example, lower government spreads might be associated with a stronger local labor market by reducing labor outflows. Alessandria et al. (2020) show that high sovereign spreads are associated with labor outflows using cross-country data. Deng (2024) finds a similar pattern using US state-level data. The net migration rate for the state of Illinois, a state with no BBR and high government spreads, has been negative and in the bottom quintile across US states for years (-1.23% in 2017, according to IRS migration dataset). Lower government spreads and better fiscal conditions could attract more workers and firms to Illinois and increase economic activity.

To highlight our main mechanism, we have deliberately simplified our model by abstracting from some assumptions that could potentially lead to different quantitative (but not qualitative) results, such as an endogenous change in BBR, lack of commitment to the existing fiscal rule, economic spillovers across different states, etc. We leave these interesting extensions for future research.

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