# State Government Debt Structure*

Oliver Giesecke

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**Abstract**

This paper documents the debt structure of state governments in the United States. Despite its economic significance for the U.S. economy, little is know about the debt structure of state governments due to severe data limitations. I develop an original machine learning approach to obtain detailed debt structure information for all state governments between 2006 and 2021. The paper shows that revenue bonds constitute the majority of all issued debt. The average duration (maturity) for outstanding debt liabilities is about 8.6 years and shows a declining trajectory over the sample period. Revenue bonds tend to be of longer duration than general obligation debt, and leases are of the shortest maturity among all debt categories. The paper tests the leading hypotheses for determinants of the debt structure in the data. I find that tight market conditions in the municipal bond market shorten the overall debt maturity structure of state issuers. Furthermore, financial strength of the issuer is robustly negatively related to the duration of the debt portfolio, regardless whether measured by fiscal fundamentals or credit spreads. The case study of the territory of Puerto Rico, which underwent a debt restructuring, shows that duration of the debt portfolio shortened substantially in the years preceding the bankruptcy announcement; thus, highlighting the interaction between fiscal fundamentals and debt maturity. The quasi-exogenous variation in credit rating that originates from Moody's recalibration of credit ratings in 2010 has little effect on duration of the debt portfolio. Further, I do not find an effect for neither the changes in the federal debt structure, nor for the SALT deduction cap on state governments' debt maturity structure.

*Keywords*: Public debt, state and local governments, maturity structure, financial fragility, interest rates, hedging, sovereign debt, debt portfolio, public finance, machine learning.
*JEL codes*: E43, E44, E62, H63, H74

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# 1 Introduction

State and local governments have a total of USD 4.0 trn. of municipal debt securities outstanding as of 2023 Q3 (Flow of Funds, 2023). Despite its large economic size, the debt structure and its determinants is largely unknown for state and local governments. This is in contrast to the rich literature on U.S. federal government debt (Krishnamurthy and Vissing-Jorgensen, 2012; Nagel, 2016; Greenwood, Hanson, Rudolph, and Summers, 2015; Jiang, Lustig, Van Nieuwerburgh, and Xiaolan, 2019; Hilscher, Raviv, and Reis, 2022) or corporations (Stohs and Mauer, 1996; Rauh and Sufi, 2010; Choi, Hackbarth, and Zechner, 2018). Multiple reasons complicate the analysis of the debt structure. First, while governmental accounting principles mandate extensive disclosures about the debt maturity structure of outstanding debt, the information is stored in long pdf documents and presented in heterogeneous formats. Second, the municipal debt market is fragmented, in-transparent, and complex, which makes the computation of credit spreads challenging.[1] This makes any association of observed bond prices to the issuer difficult. As a result of these challenges, there is little transparency about the debt structure of state and local governments nor is there much analysis of factors that affect the debt structure.

This paper closes this gap in the literature by documenting the composition and maturity profile of state governments' debt structure between 2006 and 2021. Furthermore, I test the leading hypotheses about the determinants of the debt structure of governments. The paper makes several contributions. First, I use custom machine learning models to collect the data. I train several vision and language models to systematically extract debt maturity information from the annual comprehensive reports of state governments. Second, I make several data and methodological innovations to calculate credit spreads in the municipal bond market. Concretely, I use the universe of continuing disclosure documents from the Municipal Securities Rulemaking Board (MSRB) to link municipal debt securities to its ultimate issuer. In addition, I develop a state-of-the-art pricing model to price the universe of municipal debt securities to obtain option adjusted credit spreads that I use in the analysis in the determinants of state governments' debt structure.[2]

[1] There are approximately 80,000 unique issuers in the municipal bond market–a reflection of the fact that governments often issue bonds indirectly through pass-trough entities and there is no easily accessible mapping between the bonds and the ultimate issuer available. Furthermore, a large share of municipal debt securities are complex financial instruments due to embedded optionality.

[2] I publish daily credit spread for a large sample of state and local governments in the municipal bond

I show several novel facts about the debt composition of state governments. First, regarding the debt and issuer characteristics, revenue bonds account for a total share of 22.62%. The second largest share is accounted for by general obligations for the general government with 19.3%. Leases account for 6.7% for the general government and 3.3% for component units and business type activities in 2021. Second, while the overall debt composition is relatively stable over the sample period, the issuer composition experiences a major shift after 2007 which reverses in 2016 and 2017. Third, the average duration for debt obligations is 8.6 across all state governments across in 2021, with a 25th and 75th percentiles of 7.8 and 10.0, which implies an inter-quartile range of 2.2. The median and the mean is considerably longer than the average maturity of the federal government debt of approximately 5.1 (Hilscher, Raviv, and Reis, 2022). Fourth, there is considerable heterogeneity across debt types. The average duration for general government general obligation bonds is 6.1 in 2021, while the average duration for revenue bonds is longer with 8.3 for general governments and 10.4 for the component units. Leases have relatively short duration with a mean duration of 5.6 for general government leases and 5.4 for component units and business activities in 2021. Fifth, I find a decrease in the mean and median of the cross-sectional duration distribution. The trajectory of the share of debt which is due within the first year mirrors the trend in duration with a constant increase. The share of debt that is due within the first three years and the debt share that is due within the first 5 years is also increasing until 2015 but stabilizes thereafter.

I test five hypotheses about the determinants of state governments' debt structure. First, I analyze how the fiscal strength of the issuers affects the debt maturity structure. I test the fiscal strength hypothesis using a measure of the fiscal fundamentals, credit spreads, and an event study of Puerto Rico's bankruptcy announcement. Second, I test the impact of changing market conditions in the macroeconomy on the debt maturity structure. The analysis examines what impact short-term interest rates, the difference between short-term and long-term yields, as well as, aggregate conditions in the municipal bond market have for the evolution of the debt maturity structure. Furthermore, I test the "fill-the-gap" hypothesis postulated by Greenwood, Hanson, Rudolph, and Summers (2014). The hypothesis postulates that issuers increase their debt issuances in those maturity segments

market at http://municipalfinance.stanford.edu/. The spreads are updated daily and thus provides a timely measure of investors' credit assessment.

from which the federal governments withdraws. Another hypothesis that I test, based on a quasi-experimental setting, is the impact of credit ratings on the debt maturity structure. Lastly, I estimate the impact of the Tax Cut and Job Act (TCJA), which imposed a cap on SALT deductions and as such constitutes an impairment on the ability to raise future tax revenues for states (Pevzner, Reinstein, Wynter, and Yao, 2022).

The fiscal strength of the state government is a robust determinant of the debt maturity structure. When measuring the fiscal strength via an aggregate fiscal score as in Duffy and Giesecke (2023b), I find that an improvement in the fiscal score by 10 points leads to a lengthening of the duration by approximately 0.13. Similarly, the share of debt decreases by approximately -0.5% and -0.7% for debt with a maturity of $\leq 1$ years and $\leq 3$ years, respectively. The effect for debt maturity of $\leq 5$ year is weaker with a magnitude of -0.7%. This finding is consistent with the hypothesis of debt as commitment vs. hedging device in the sovereign debt context where short-term debt provides incentives to repay (Hart and Moore, 1994, 1998), while long-term debt provides hedging benefit against a change in market conditions (Arellano and Ramanarayanan, 2012). This results is corroborated when measuring the financial strength by credit spreads in the municipal bond market. I find that an increase in the credit spread by one percent is associated with a decline in the duration by 4.4%. Lastly, I study the case study of Puerto Rico that filed for bankruptcy protection in 2017. I find a substantial shortening of the duration of the debt portfolio preceding the bankruptcy announcement, with a sharp acceleration in the last year, which supports the relationship between fiscal strength and debt maturity. The finding shows some parallel to a well documented fact in the context of firms. Mian and Santos (2018) show that high credit quality firms are more sensitive in its timing to credit conditions and are able to obtain longer maturities to hedge future interest rate rises then less creditworthy firms. Relatedly, Rampini, Sufi, and Viswanathan (2014) show that airlines that are more financially constrained hedge fuel price risk less both in the cross section and within airlines over time.

The quasi-exogenous variation in credit rating that originates from Moody's recalibration of credit ratings in 2010 has little effect on duration of the debt portfolio. I do not find any statistically significant change in the composition of state governments' debt, measured by duration, the 1 year share, 3 year share, and 5 year share.

Similarly, the change in the debt maturity structure of the U.S. federal debt as induced

by large scale asset purchases by the Federal Reserve, did not lead to a detectable change in state governments' debt maturity structure. As such the evidence does not support the "fill-the-gap" hypothesis (Greenwood, Hanson, and Stein, 2010) that state government debt serves as a substitute to federal government debt; if at all, I find evidence that suggests complementary with regards to the debt maturity structure.

Another major legislation that had the potential to affect the equilibrium in the municipal bond market is the cap on SALT deduction cap and the restriction of tax-exempt refinance operations as part of the Tax Cut and Jobs Act (TCJA). While being a major legislation, I find only minor changes in the debt maturity structure that are not statistically significant.

**Literature Review** I contribute to several strands of the literature. First, I contribute to the literature on debt structure of sovereign debt. Arellano and Ramanarayanan (2012) develops a dynamic model to study the maturity composition of defaultable sovereign debt. The model explains the empirical fact that a rise in interest rate spreads (over U.S. treasuries) is associated with shortening of debt maturity and a larger increase in short spreads than long spreads. The inherent trade-off is between the *incentive effect* of short term debt and the *hedging benefit* of long-term debt. The incentive effect is related to the lack of enforcement as in Hart and Moore (1994, 1998). Diamond and He (2014) provides a new theoretical insight that short term debt can impose stronger debt overhang than long-term debt in a dynamic environment; this is in contrary to the previous literature. The main mechanism is that short term debt shares less risk of future volatility. Hence, equity bears more risk than under long-term debt which affects the equity valuation and thus exacerbates debt overhang. Carlson, Giammarino, and L Heinkel (2022) link the optimal capital structure of municipalities to their investment intensity by trading of the implications on the tax base and the cost of resolving financial distress. Bhandari, Evans, Golosov, and Sargent (2017) provide an analytical framework that link the optimal government debt level in incomplete markets. Hilscher, Raviv, and Reis (2022) studies the debt structure of the federal government in the context of the debt devaluation potential of inflation. The paper finds that the duration of the U.S. government debt portfolio is approximately 5.1 as of the end of 2017. Thus, inflation surprises, which are small and have little persistence, are unlikely to significantly reduce the federal debt burden. Greenwood, Hanson, Rudolph, and

Summers (2014) outline a new institutional arrangement between the U.S. Treasury and the Federal Reserve for debt management. Greenwood, Hanson, Rudolph, and Summers (2015) provide a framework for government debt management in the presence of frictions that depart from the frictionless Ricardian world, trading off four potentially competing objectives.

Second, I connect to the literature on capital structure of firms. Rauh and Sufi (2010) shows substantial variation in the capital structure of firms depending on the credit quality. Specifically, the paper shows that low-credit-quality firms are more likely to have a multi-tiered capital structure, including secured and unsecured debt, relative to high-credit-quality firms. Greenwood, Hanson, and Stein (2010) postulates that firms' capital structure reacts to the demands of the investors in the market. The paper builds on three main ingredients: (i) preferred habitat in the credit market, (ii) large supply shock in the credit market; here the debt composition of the federal government, (iii) presence of arbitrageurs with limited capital. In this setting firms can supply debt securities to cater to the demands of investors; in the language of the authors they can "fill-the-gap". Mian and Santos (2018) provides evidence on market timing of corporations in the credit market. The authors draw on new loan level micro data from the Shared National Credit Program. They find important heterogeneity across firms. High credit quality firms are more sensitive to good credit conditions and are able to obtain longer maturities to hedge future interest rate rises then less creditworthy firms. The authors also find a strong relationship between refinancing and subsequent capital expenditures. Choi, Hackbarth, and Zechner (2018) shows that firms increase its dispersion in the debt maturity structure following a shock that increases roll-over risk. The main trade-off in their model is between the higher total issuance cost and lower liquidity for a dispersed debt maturity portfolio vs. the roll-over risk for a concentrated debt maturity portfolio.

Third, there is a small literature that studies the implication of policy changes on the municipal bond market. Ambrose, Gustafson, Valentin, and Ye (2023) and Pevzner, Reinstein, Wynter, and Yao (2022) study the implications of the Tax Cuts and Jobs Act's (TCJA) on municipal borrowing cost. Pevzner, Reinstein, Wynter, and Yao (2022) argues that TCJA weakens the relationship between the ability to raise real estate revenues and municipal bond spreads. Ambrose, Gustafson, Valentin, and Ye (2023) argue that the TCJA raised the cost for local public goods and thus credit spreads; the effect was large in jurisdiction

with stricter voter approval requirements for municipal debt issuance. Bergstresser (2023) provides an excellent review of the unique characteristics of municipal bonds and recent regulatory changes. Municipal Securities Rulemaking Board (2022) summarize the trends in the ownership structure of municipal debt securities over the last 20 years and Garrett (2021) highlights the agency conflicts between financial advisors and underwriters in the municipal bond market.

Fourth, I connect to the growing literature on state and local finances. Adelino, Cunha, and Ferreira (2017) study the effect of municipalities' financial constraints on local employment and growth. The paper uses the exogenous re-calibration of Moody's rating methodology in 2010 (Moody's Investors Service, 2010). The paper finds that with the loosening of credit constraints, local government increase expenditures following the rating upgrade. Closely related is an earlier literature on institutional constraints on fiscal policy (Bohn and Inman, 1996; Poterba, 1994, 1995).

Relatedly, the paper contributes to the understanding of liabilities of state governments. Giesecke and Rauh (2022) show that unfunded pension promises account for the largest liability for state governments. Giesecke and Rauh (2022); **?**); Novy-Marx and Rauh (2009) study the valuation of liabilities that are related to pension benefit promises that state and local governments have made. They find that the reported pension obligations understates the true pension obligation by a considerable amount. As the end of fiscal year 2021, they estimate that the market value of states' unfunded pension obligation is $5.43 trn. Furthermore, Duffy and Giesecke (2023b) shows the asymmetric treatment of pension of debt obligations during chapter 9 bankruptcies and Boyer (2018) shows the seniority of pension debt over debt obligations in the municipal bond market.

I proceed as follows: Section 2 describes the data extraction and data components. Section 3 provides descriptive statistics statistics. Section 4 analysis the empirical determinants of the capital structure of state governments. Section 5 concludes.

# 2 Data

## 2.1 Municipal Bond Data

I measure municipal bond yields in the primary and secondary market. Primary market information are obtained from Mergent Municipal Bond Database which records issuer characteristics and a large set of bond characteristics. In addition, I obtain secondary market data from MSRB EMMA. MSRB EMMA is a trade repository which records every trade in municipal bond securities since 2005. MSRB EMMA includes the trade time, trade price and implied yield to maturity, as well as, information whether it was a broker to customer trade or broker to broker trade.

**Challenge 1: Connect municipal debt instruments to the ultimate issuer** One challenge is to establish the connection between the bond issuance and the bond issuer. While Mergent Bond Database records the issuer name, the match to the financial information of the issuing entity is not straightforward. I overcome this challenge by drawing on the universe of debt security disclosures under the U.S. Securities and Exchange Commission (SEC) Rule 15c2-12 as provided by MSRB.[3] The SEC requires to report all debt securities that are related to an financial statement of the issuer and thus allows me to identify all instruments that are associated with an obligor.

**Challenge 2: Price municipal debt instruments accurately** Municipal debt instruments main purpose is to finance government operations and capital investments. In principle, a plain-vanilla zero coupon or coupon bond fulfills the need, However, municipal securities are surprisingly complex. About 60% of all instruments have embedded optionalities. One of the most prevalent embedded optionality are call options. A call option provides the issuer with the optionality to redeem the bond prematurely at the call price. That is, if interest rates decline and bond prices increase, the issuer can redeem the bond at the (lower) call price. This optionality has value as it can be used opportunistically and asymmetrically. Ignoring the call option would thus lead to an overstatement of the credit spread because the spread not only compensates the investor for the risk taken but also for the option

[3]This methodology follows Giesecke, Mateen, and Sena (2022).

granted to the issuer. A typical convention is thus to calculate the option adjusted spread.[4] Prior literature, for example Babina, Jotikasthira, Lundblad, and Ramadorai (2021), omits all bonds with options to circumvent this challenge.

I overcome this challenge by developing a state-of-the-art pricing model to obtain the option adjusted credit spread for the the universe of municipal debt securities. The pricing model is able to compute the option adjusted credit spread considering the value of the embedded call and put options, early prepayment options, sink schedules, redemption schedules and all combinations thereof.[5]

## 2.2 Debt Structure Data

The information on the debt structure of state governments is granular but difficult to access. I use the financial disclosures in the annual comprehensive financial reports (ACFRs), which are the equivalent to the annual reports of corporations. These reports contain detailed information on the financial position of state and local governments, including information on the debt structure. The disclosures in the reports follow the financial reporting standards for U.S. state and local governments, called Generally Accepted Accounting Principles (GAAP) and are set by the GASB. With regards to the debt structure, GASB standard No. 38 requires detailed disclosures about the maturity structure of outstanding debt. It requires a tabulation of the cash flows for each year in the next five years and a disclosure of cash flows by five year maturity increments thereafter. The information has to be disclosed separately for each debt category and each governmental unit of issuance. These categories include, principal and interest for general obligation bonds, revenue bonds, notes payables, direct placements, etc. for the primary government, business-type activities, and component units, amongst others.

While the ACFRs are rich in information, it has historically been difficult to extract this information at scale. The ACFRs are published predominantly as machine readable, sometimes not machine readable, pdf documents. Thus it is extremely difficult to collect this data systematically. To provide a sense about the scale: for the 50 state governments; the District of Columbia and Puerto Rico, and 16 years of data, with approximately 500

[4] E.g. Bloomberg offers computation of option adjusted spread (OAS) as part of their BVAL package.

[5] The results for a broader sample universe including recent updates are available at the Stanford public finance dashboard, which is available at https://municipalfinance.stanford.edu.

pages each, the documents contain approximately 420,000 pages from which tables have to be extracted. Thus, I leverage recent advances in vision and large language models for the data extraction and processing.

**Challenge 1: Information about debt structure is stored in pdf documents (ACFRs)** I create custom training and validation data by manually labelling approximately 1,500 pages of data by identifying the relevant tables, assigning a table category and the unit of account in the table. I then train a state-of-the-art vision model to recognize tables and table titles. The use of a (multi-modal) vision model that uses both layout information and textual information achieves an impressive accuracy of $> 99.9\%$ as per evaluation in the test dataset.[6] The process is visualized in Appendix Figure A.5.

**Challenge 2: Format is heterogeneous (units, debt categories, table presentation)** I also train a custom classifier to distinguish between two government unit types, that is, general government and component units (and business type activities). Another challenge is the heterogeneous unit of account. The ACFRs provide debt information in $ billions, $ millions, $ thousands, or dollars. The analysis requires to express all data in a common unit and thus requires the extraction of the unit information and a normalization in the post-processing step. I solve this challenge by training a custom language model that is specifically designed to return the unit of the table. As a result, I obtain a total of four custom models that transform the raw pdf documents into an intermediary dataset that provides the debt maturity table and important meta information such as the unit and the table category. The process is visualized in Appendix Figure A.6.

Lastly, I have to transform the intermediate output into a final dataset that is homogenous across entities and years. The large degree of heterogeneity in the representation of the information on governments' ACFRs makes a deterministic manipulation close to impossible. Instead I lever a state-of-the-art large language model (LLM) to transform the data and use deterministic data manipulation techniques subsequently for post-processing of the data. The process is visualized in Appendix Figure A.7.

[6]The test dataset is held out of the training and validation procedure and thus represents an unbiased evaluation of the accuracy in an unseen part of the data.

**Debt Maturity Profile Measurement** The processed data provides detailed information about the debt maturity profile, that is, for each year I obtain the dollar amount that is due for the respective entity. This debt maturity profiles provides a lot of transparency about the cash flows that are due in each year. A well established concept in the fixed income literature that summarizes the timing of individual cash flows is duration. It measures the time weighted average maturity of a cash flow stream. In addition, the duration has another economically important interpretation. Duration, as measured by the modified Macaulay duration, provides the percent change in net present value of the debt instrument if the interest decreases by one percent. Thus, a duration of 5 years means that the value of the debt portfolio would increase by 5% if the interest rate decreases by one percent. Thus, duration provides a convenient measure to both summarize the maturity structure, as well as, expressing the sensitivity to interest rates. There are alternative measures to summarize the debt maturity structure. These include the share of debt, including interest and principal, that is due within the next year, next three years, and the next five years. These measures are of more local nature as they focus on the cash flow obligations in a specific maturity spectrum. The local nature comes at the advantage, in comparison to the global duration measure, that it zooms into specific segments of the maturity spectrum. Specifically, the short-term measures are insightful because they capture cash-flow obligations with the greatest immediacy and cash outflows in the absence of a refinancing or roll-over operations.

## 2.3 State Finance Fundamentals

Corporate finance has a long history of using financial ratios to assess the financial condition of companies. Duffy and Giesecke (2023a) provide an analogous financial ratio approach for state and local governments. The paper covers all state governments and the largest 500 local governments across the United States.[7] The authors measure the fiscal strength along 10 important dimensions, which include the liquidity and reserve position, leverage, as well as, pension and other post-employment benefit obligations, and funding pressure related to pension and other post-employment benefits. In addition, the paper provides an aggregate financial strength measure which aggregates all dimensions into a

[7]The interactive version of the states' financial fundamentals is accessible via the Stanford public finance dashboard, which is available at https://municipalfinance.stanford.edu/apps/page_state_fund_comp.

final score. This aggregate financial score is what I will use throughout the paper.

# 3 Summary Statistics

This section tabulates the summary statistics for the cross-section and the time series of the debt structure of state governments in the United States. The summary statistics provide an unprecedented view into how state governments' debt structure has evolved. The first set of summary statistics focus on the debt composition, that is, the debt type and the issuer characteristics of state governments' debt. The second set details the debt overall debt maturity structure and breakdowns of the debt maturity by debt category and governmental unit.

State governments' debt can be broken down along two major dimensions, that is, the debt type and the governmental unit that issues the debt. Specifically, I distinguish between four debt types: General obligation debt ("GO"), debt that is backed by revenues ("Revenue"), leases and debt that does not fall in any of the aforementioned categories ("Other"). The "other" category comprises e.g. certificates of participation, notes, bank debt, and debt for which the debt category is not explicitly mentioned in the annual report. The other dimension is the governmental unit that issues the debt. I distinguish between the general government ("GGOV") and component units and business type activities ("COMPBA").[8] A small share of debt can neither be allocated to the general governments or component units and business type activities and is categorized as "other" in the following.

**Cross-Sectional Debt Composition** First, I will present the cross-sectional debt composition in 2021–the last year for which complete data for all state governments is available. Table 1 tabulates the cross-sectional summary statistics of the share of outstanding debt by debt type and governmental unit.[9]

The general obligations for the general government account for the largest share of outstanding debt with 19.3%. Revenue bonds account for the next two largest categories with 12.3% for the general government and 10.3% for component units and business type activities. Thus the total share of revenue bonds exceeds share of general obligation debt.

[8]GASB Statement No. 14 determines the financial reporting entity. Component units and business type activities are to be included in the financial statement if the primary component is financially accountable for these entities.

[9]This is the summary statistics of the cross-sectional share. Thus, it represents the cross-sectional distribution which treats each state identically irrespective of the relative size of the debt outstanding.

Leases account for 6.7% for the general government and 3.3% for component units and business type activities. The debt that cannot explicitly assigned to any of the categories accounts for a substantial share.

| Share of Present Value | Mean | Median | p25 | p75 | SD | N |
|---|---|---|---|---|---|---|
| compba_go | 0.44 | 0.00 | 0.00 | 0.00 | 2.23 | 5 |
| compba_leases | 3.28 | 0.06 | 0.00 | 2.09 | 14.06 | 28 |
| compba_other | 21.34 | 6.80 | 0.00 | 35.88 | 27.86 | 37 |
| compba_revenue | 10.28 | 0.00 | 0.00 | 12.36 | 19.70 | 25 |
| ggov_go | 19.33 | 4.66 | 0.00 | 35.43 | 24.32 | 30 |
| ggov_leases | 6.67 | 2.95 | 1.19 | 4.67 | 17.14 | 49 |
| ggov_other | 19.63 | 9.49 | 1.02 | 24.12 | 25.40 | 42 |
| ggov_revenue | 12.34 | 0.00 | 0.00 | 15.29 | 22.00 | 25 |
| other | 6.70 | 0.00 | 0.00 | 2.61 | 17.13 | 26 |
| total | 100.00 | 100.00 | 100.00 | 100.00 | 0.00 | 51 |

Table 1: Summary Statistics - 2021 Debt Composition by Debt Type

*Notes:* The values in the table are expressed in percentages (%), except for the 'N' column, which represents the number of non-missing data.

**Debt Type Composition - Time Series** Besides the cross-sectional summary statistics, the data allows to show the change in the debt type composition over time. Figure 1 shows the relative share of each debt type between 2006 and 2021. Over the sample period the overall debt composition is relatively stable. Mirroring the cross-sectional distribution in 2021. Revenue debt is the largest single category, followed by general obligation debt and leases.

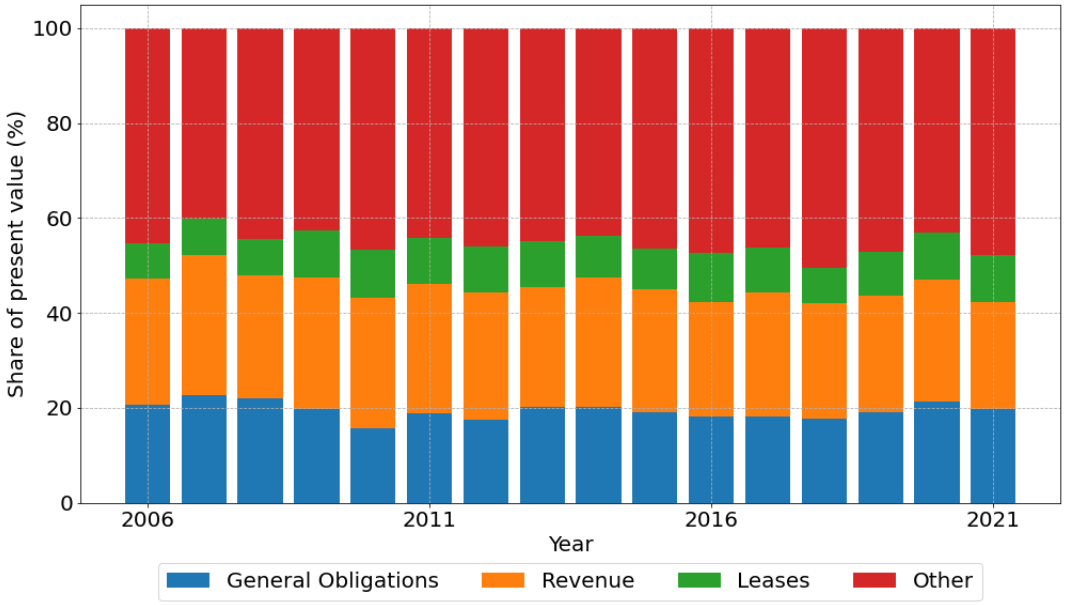



Figure 1: Change in Debt Composition by Debt Type

*Notes:* The figure shows the evolution of the mean share for each debt type over the sample period.

**Debt Issuer Composition - Time Series** Similar to the changes in the debt type over time, Figure 2 shows the debt issuer composition over the sample period. The issuer composition experiences a major shift towards the beginning of the sample. Between 2007 and 2013, the share of debt issued by the general government increases from around 65% to more than 80%. This trend reverses in the second half of the sample period. Between 2013 and 2017, the share of the general government falls to less than 60%.

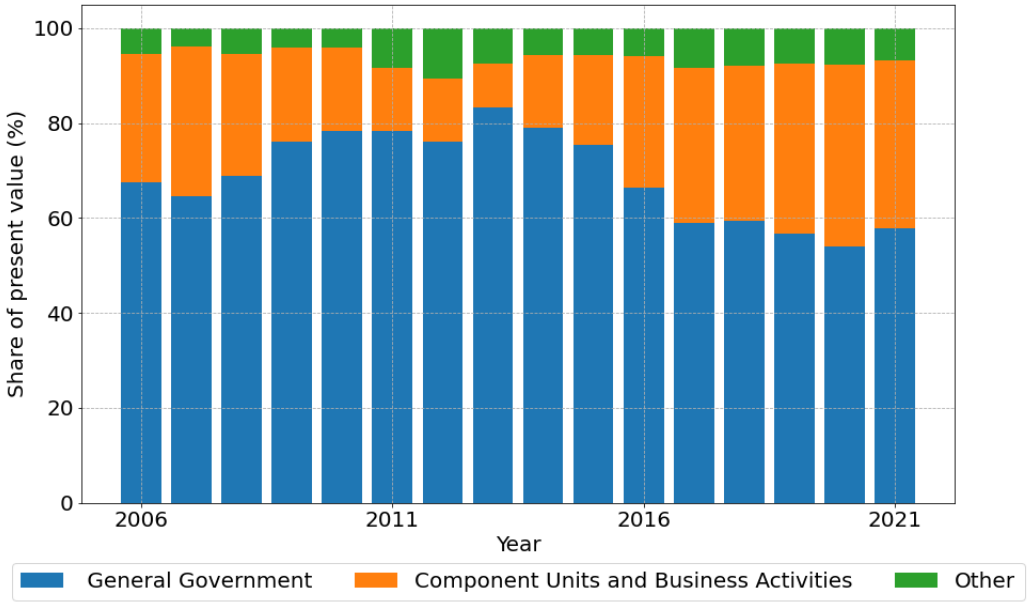



Figure 2: Change in Debt Composition by Governmental Unit

*Notes:* The figure shows the evolution of the mean share for issuer composition over the sample period.

**Debt Maturity** Another important dimension of the debt composition is the maturity structure. The maturity structure describes when the outstanding debt has to be repaid—both interest and principal. Governmental accounting standards, specifically GASB 39, require a disclosure of the principal and interest that is due in each of the following five years; and a disclosure of the cash flows in five year maturity buckets thereafter. The detailed information about the cash flow structure of debt provides a high-dimensional object that is difficult to analyze empirically. Thus, I use four summary measures of the debt maturity structure; namely, the modified Macaulay duration, the share of debt that is due within the next year, next three years, and the next five years, as outlined in Subsection 2.2.

The average duration for debt obligations is 8.6 across all state governments across in 2021, with a standard deviation of 2.1. The 25th and 75th percentile are 7.8 and 10.0, which implies an inter-quartile range of 2.2. To put these numbers into context, according to Hilscher, Raviv, and Reis (2022), the average maturity of the U.S. government debt is approximately 5.1 as of the end of 2017.[10] Thus, state governments tend to issue debt

[10]The authors use maturity instead of duration. Duration is likely to be shorter since most debt securities of the federal government pay coupons. Changes since 2021 have likely shortened overall maturity structure due to debt purchases of the Federal Reserve against the issuance of reserves. However, the Treasury

instruments with longer duration than the federal government. This result is not driven by outliers: even the 10th percentile in the cross-sectional duration distribution remains above seven years over the entire sample period as Figure 3 shows.

The average duration shows some heterogeneity across debt types. The average duration for general government general obligation bonds is 6.1 in 2021. In comparison, the average duration for revenue bonds is longer. In 2021 the average duration for general government is 8.3 and 10.4 for the component units. The longer duration of the revenue bonds reflect the fact that revenue bonds are repaid by the generated revenues from the projects they finances. Hence, the repayment horizon is partly aligned with the revenue horizon of the project. Since many capital projects have longer duration; so does the debt that finances them. Finally, leases are the liability that tend to be at the shorter end of the duration distribution. General government leases have a mean duration of 5.6 and component units have an average duration of 5.4 in 2021. The full result are tabulated in Table 2.

| Duration | Mean | Median | p25 | p75 | SD | N |
|---|---|---|---|---|---|---|
| compba_go | 7.55 | 6.76 | 6.68 | 6.83 | 2.42 | 5 |
| compba_leases | 5.38 | 5.28 | 3.71 | 6.59 | 2.69 | 28 |
| compba_other | 9.34 | 8.86 | 7.52 | 10.75 | 2.67 | 37 |
| compba_revenue | 10.39 | 10.00 | 8.61 | 11.42 | 3.91 | 25 |
| ggov_go | 6.14 | 6.37 | 4.71 | 7.30 | 2.27 | 30 |
| ggov_leases | 5.62 | 5.28 | 3.58 | 6.55 | 2.98 | 49 |
| ggov_other | 7.51 | 7.05 | 5.66 | 8.64 | 3.93 | 42 |
| ggov_revenue | 8.29 | 8.53 | 6.92 | 10.16 | 2.99 | 25 |
| other | 9.37 | 9.08 | 7.32 | 11.19 | 4.54 | 25 |
| total | 8.63 | 8.62 | 7.78 | 10.01 | 2.12 | 51 |

Table 2: Summary Statistics - 2021 Debt Maturity by Debt Type

*Notes:* The values in the table are the summary statistics of the Macaulay duration of all state governments + District of Columbia in 2021. The 'N' column represents the number of non-missing observations. "compba" and "ggov" represents component units and business activities and general government, respectively. "go" means general obligation bond, "revenue" are revenue bonds and "leases" consist of capital and operating leases. "other" represents debt that cannot to categorized as any of the aforementioned categories.

**Debt Maturity Trajectory** The previous section outlined the cross-sectional moments of the debt duration in 2021. For the time series dimension of the longitudinal dataset Figure

department typically offsets some of the decline in the average maturity by issuing longer-term securities (Greenwood, Hanson, Rudolph, and Summers, 2014).

3 visualizes the mean, the 10th, the 25th, the 50th, the 75th, and the 90th percentile of the cross-sectional distribution across the 50 states and the District of Columbia for each year in the sample. Figure A.1 show the equivalent moments for the share of debt that is due within 1 year, 3 years, and 5 years. These figures provide a more nuanced view into the short end of the debt maturity structure.

Figure 3 shows that with the exception of a small increase between 2006 and 2007 the mean of the cross-sectional duration distribution is decreasing over the sample period. A similar trend is visible for the median. It appears, however, that the decline in the median flattens out around 2015 and stabilizes thereafter. Both the inter-quartile range, as well as, the difference between the 10th and 90th percentile remain stable over the sample period. Overall, all moments of the cross-sectional distribution mirror the discussed trajectory of the mean and median.

The trajectory of the share of debt which is due within the first year mirrors the trend in duration. As duration is decreasing over the sample period, that is, the average maturity is shortening, the debt share which is due in the first year is increasing. The increase is persistent over the sample period as shown in Figure A.1a. The increase in the debt share that is due within the first three years is also increasing between 2006 and 2015 but plateaus thereafter as shown in Figure A.1b. A similar pattern is visible for the debt share that is due within the first 5 years. The median is increasing until 2015, is stable thereafter and decreasing mildly in 2020 and 2021 relative to 2015 as shown in Figure A.1c.

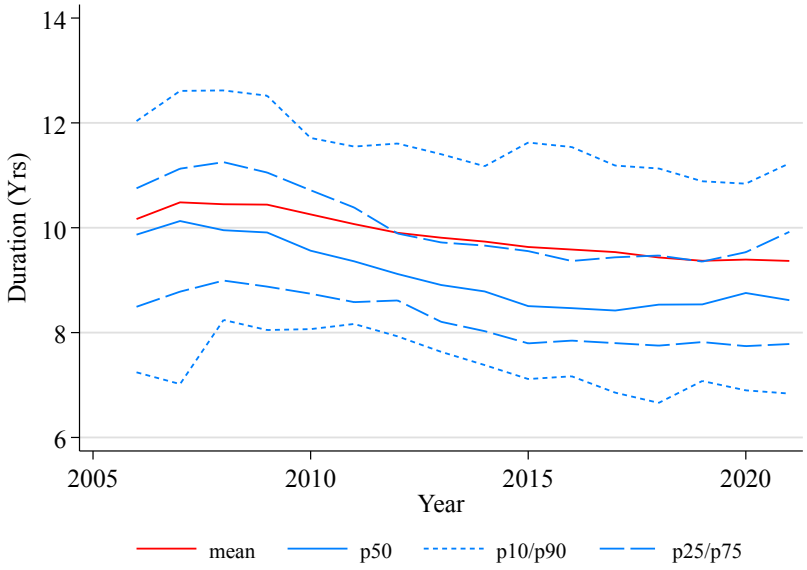



Figure 3: Cross-Sectional Moments of Duration

*Notes:* The figure visualizes the mean, the 10th, the 25th, the 50th, the 75th, and the 90th percentile of the cross-sectional duration distribution across the 50 states and the District of Columbia for each year of the sample.

# 4 Empirical Analysis

This section tests several hypotheses about the determinants of state governments' debt structure. Subsection 4.1 investigates the impact of changing market conditions in the macroeconomy on the debt maturity structure. The analysis examines what impact short-term interest rates, the difference between short-term and long-term yields, as well as, aggregate conditions in the municipal bond market have for the evolution of the debt maturity structure.

Macroeconomic market conditions are common across all issuers; while states' fiscal strength varies in the cross-section and over time. I study the relationship between fiscal strength and debt maturity structure via three different approaches. First, I use the aggregate fiscal strength score as constructed by Duffy and Giesecke (2023a) to measure the fiscal fundamentals of a state based on its financial disclosures. The fiscal strength score aggregates 10 dimensions that measure liquidity and reserve position, pension and OPEB funding, among others. The analysis is presented in Subsection 4.2. Second, I use the state's credit spreads which represents the investors credit assessment. A rational in-

vestor requires a compensation for the credit risk he or she takes. The analysis is shown in Subsection 4.3. Third, I study one of the most salient events of municipal fiscal distress in U.S. history, the "bankruptcy" announcement of Puerto Rico, in Subsection 4.4.[11] The bankruptcy announcement came after a long episode of fiscal distress and provides an excellent case study to observe the adjustment of the debt maturity structure in the face of severe fiscal distress.

Subsection 4.6 tests for the "fill-the-gap" hypothesis (Greenwood, Hanson, Rudolph, and Summers, 2014). The hypothesis postulates that issuers increase their debt issuances in those maturity brackets from which the federal governments withdraws. The hypothesis was originally formulated in the context of corporate debt but may analogously apply to the debt of state governments. I use the shifts in the federal government's debt structure as a result of the asset purchases of the Federal Reserve after the Great Financial Crisis and COVID-19 to test this hypothesis.

Another interesting question is the effect of a credit rating assessment on the debt structure of state governments. In 2010 Moody's changed its rating methodology which changed the credit ratings for numerous state and municipal issuers. Adelino, Cunha, and Ferreira (2017) show that the resulting change in credit ratings loosened credit conditions and increased spending at the municipal level. I use this rating change as a proxy of changing investors' perception of the creditworthiness to understand their impact on states' debt structure. The analysis in shown in Subsection 4.5.

Another event of potentially substantial impact is enactment of the Tax Cut and Job Act (TCJA) in 2017, which I study in Subsection 4.7. The TCJA imposed a cap on SALT deductions and as such constitutes an impairment on the ability to raise future tax revenues for states (Pevzner, Reinstein, Wynter, and Yao, 2022). I use the variation in the cross-sectional exposure of states to understand the implications on the debt maturity structure of state governments.

## 4.1 Macroeconomic Market Conditions

The literature on the U.S. federal debt has discussed how the federal governments should manage its debt. These discussions comprise a variety of suggestions, including the is-

[11] Puerto Rico remains legally barred from using Chapter 9, the bankruptcy code usually taken by insolvent local governments. Instead Puerto Rico announced a restructuring under Title III of the PROMESA law.

suance of floating rate perpetuities (Cochrane, 2015) to the deliberations of various trade-offs in the conduct of fiscal and monetary policy (Greenwood, Hanson, Rudolph, and Summers, 2014, 2015).

Traditional debt management considerations emphasize two important dimensions: First, the debt maturity structure determines the exposure to refinancing risk. If the government issues short-term debt, it is exposed to increases in interest rates, while with long-term debt, it 'locks in' the cost of capital (Greenwood, Hanson, Rudolph, and Summers, 2014).[12] One of the empirical predictions is that I should see an extension of the maturity structure when long-term interest rates are low (Cochrane, 2023). Another important dimension is the management of roll-over risk. A government is exposed to roll-over risk when it has to repay a maturing debt issue by new debt and thus relies on the market to absorb the new debt. Generally, roll-over risk is highest during times of market distress which I measure through the credit spread between a municipal bond market benchmark yield and the duration matched treasury yield.[13] From the aforementioned discussion, there are two empirical predictions: First, the managing of refinancing risk suggests that the debt maturity structure should be extended when interest rates are low and the slope of the term structure is flat. Moreover, the managing of the roll-over risk suggests an extension of the debt maturity structure during periods of increased credit spreads. However, at the same time, higher contemporaneous credit spreads in the market may constrain the issuer to issue long-term debt as short-term debt aligns incentives of repayment (Arellano and Ramanarayanan, 2012).

In contrast to the first hypothesis, I find that higher short term interest rates, as well as, yield spreads are associated with longer duration and a lower share of the short-term debt maturity shares. Regarding the second hypothesis, I find that higher credit spreads in the municipal bond market are generally associated with shorter debt duration and higher shares of shorter maturity debt. The full set of estimates is displayed in Table 3.

[12] Greenwood, Hanson, Rudolph, and Summers (2014) considers additional dimensions for the federal government that are less relevant for state governments.

[13] I use the Municipal Market Advisor AAA 5% coupon curve for 5 year maturity bonds, which is a commonly used as a benchmark in the municipal bond market.

| | Duration (Yrs) | Share $\leq 1yr$ | Share $\leq 3yrs$ | Share $\leq 5yrs$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| 2-yr ZC treasury yield | 0.679*** | -0.737*** | -1.820*** | -2.753*** |
| | (0.0540) | (0.124) | (0.193) | (0.263) |
| 5-yr muni credit spread | -0.912*** | 0.600 | 1.878*** | 3.332*** |
| | (0.168) | (0.423) | (0.528) | (0.772) |
| 2-10yr yield spread | 0.716*** | -0.936*** | -2.172*** | -3.201*** |
| | (0.0659) | (0.202) | (0.180) | (0.239) |
| $R^2$ | 0.753 | 0.572 | 0.692 | 0.673 |
| State FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 829 | 829 | 829 | 829 |

Table 3: Market Conditions and Debt Maturity Structure

*Notes:* Zero coupon (ZC) treasury bond yields come from Bloomberg. The 2-10 yr yield spread is measured as the difference between the 10 year and the 2 year ZC treasury yields. The municipal credit spread is measured as the difference between the Municipal Market Advisor AAA 5% coupon curve for 5 year maturity bonds and the corresponding ZC treasury yield. This credit spread represents the market conditions of top-rated municipal debt securities relative to the Treasury market.

## 4.2 Fiscal Fundamentals

This section studies the relationship between the fiscal fundamentals and the debt maturity structure. Fiscal fundamentals are measured by 10 financial ratios that capture several aspects of states' financial conditions (Duffy and Giesecke, 2023a). I use the aggregate financial strength score which represents an aggregation of the 10 individual scores. A detailed explanation of each dimension and the aggregation is presented in Duffy and Giesecke (2023a). I explore both the longitudinal predictability of the changes in the debt maturity structure by the changes in the score, as well as, the cross sectional variation in the debt maturity structure by the level in the score.[14]

**Year-over-year differences** I first study the relationship between the year-over-year changes in the the financial conditions of the state and the year-over-year changes in debt maturity structure. The longitudinal nature of the dataset allows me to include year and state fixed effects. Thus, I am able to absorb time-invariant factors at the state level, as well as, factors that affect all states equally in a given year.

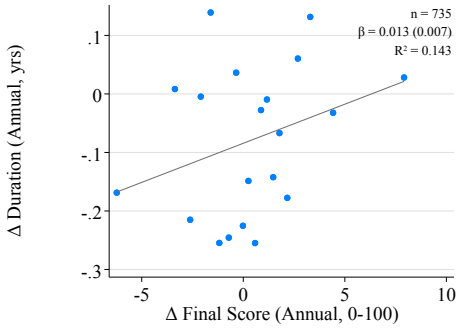
Overall, I find that and improvement in the fiscal score leads to an lengthening in the

[14]Note that one of the components of the financial score is impacted by the level of debt that the state has. However, the score is not directly impacted by the debt maturity structure. Thus, mechanical endogeneity is less of a concern.

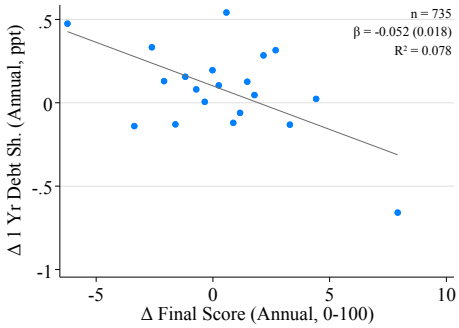
debt maturity profile. Concretely, I find that the duration lengthens by approximately 0.13 years for an improvement of the financial score by 10 points. Similarly, the share of debt decreases by approximately -0.5% and -0.7% for debt with a maturity of $\leq 1$ years and $\leq 3$ years, respectively. The effect for debt maturity of $\leq 5$ year is weaker with a magnitude of -0.7% for an improvement of 10 point in the financial score. Figure 4 displays the relationship between the fiscal strength indicators and several measures of the state debt maturity structure in binscatters. The numerical estimates are for several fixed effect specifications are tabulated in Table 4.

One of the concerns is that there is a contemporaneous determination of the financial strength score and the debt maturity structure. Thus, I show robustness of the results in Figure A.2 that uses the lagged fiscal strength indicators. The results are qualitatively comparable, though slightly weaker in magnitude. Alternatively, this results may also indicate a dynamic adjustment mechanism. This means that the adjustment to the debt maturity structure are not entirely performed in the first year but that some adjustment is done in the following year. Furthermore, I test for the relationship between the change in the financial score and the debt maturity at low frequency. Specifically I use the change in the debt maturity structure between 2006 and 2021, and find essentially no relationship. The results for this long-term changes are shown in Appendix Figure A.3.

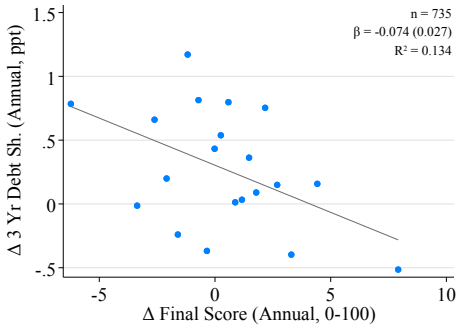
**Level Relationship** I further test to what extent the fiscal strength is related to the level in the debt maturity measure. This is a much weaker test than the analysis in changes as many confounding variables can affect both the fiscal strength and the debt maturity simultaneously. Figure 5 shows the results. I find a weak positive relationship between the fiscal strength score and the duration. That is, state governments that have stronger fiscal fundamentals have on average a longer debt maturity of their bond portfolio. Interestingly, the longer duration is not driven by the share of debt that is due within 1 year, 3 years and 5 years as panels (b) - (d) of Figure 5 show. Thus, the longer duration is primarily driven by longer maturity bonds. I further conduct robustness of this result by using the lagged level of the fiscal strength score as shown in Appendix Figure A.4.



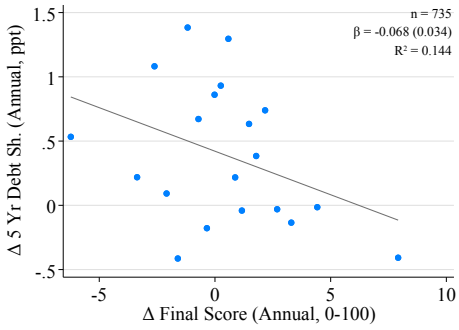

(a) Δ Duration vs. Δ Financial Score, Annual




(b) Δ ≤1 Yr Debt Share vs. Δ Financial Score, Annual



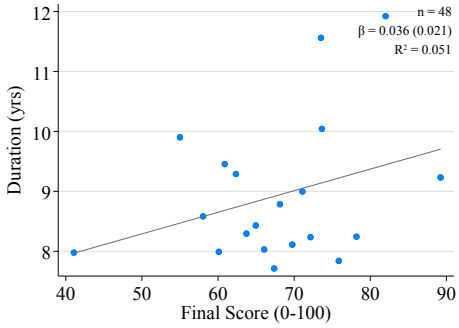

(c) Δ ≤3 Yr Debt Share vs. Δ Financial Score, Annual



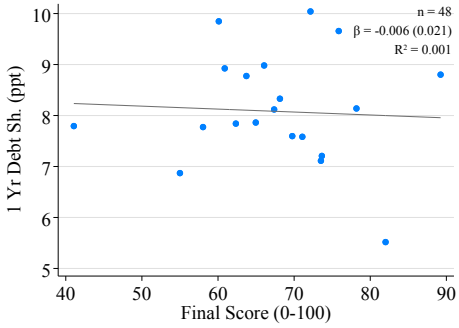

(d) Δ ≤5 Yr Debt Share vs. Δ Financial Score, Annual

Figure 4: Short Term Changes (Annual) in Duration, ST Debt Proportion vs. Financial Score

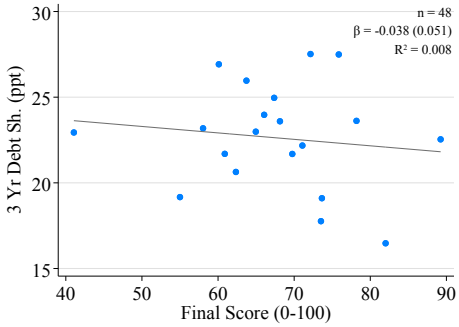
*Notes:* The figure shows the relationship between the changes of four measures of debt maturity structure and the annual change of the financial strength score. All figures shows the bivariate relationship between the score and the outcome variable after residualizing state and year fixed effect. The relationship is presented via binscatters with 20 bins. The sample encompasses all states in the United States between 2012 and 2021. More details about the data can be found in Section 2.



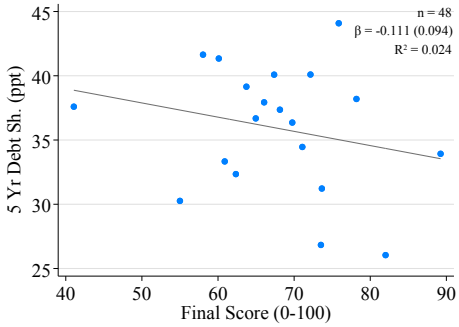

(a) Duration vs. Financial Score, 2021




(b) ≤1 Yr Debt Share vs. Financial Score, 2021




(c) ≤3 Yr Debt Share vs. Financial Score, 2021




(d) ≤5 Yr Debt Share vs. Financial Score, 2021

Figure 5: Duration, ST Debt Proportion vs. Financial Score, 2021

*Notes:* The figure shows the relationship between the four measures of debt maturity structure and the financial strength score in 2021. All figures shows the bivariate relationship between the score and the outcome variable. The relationship is presented via binscatters with 20 bins. The sample encompasses all states in the United States. More details about the data can be found in Section 2.

| | Δ Duration (Annual) | | Δ ≤1 Yr Debt Share (Annual) | | Δ ≤3 Yr Debt Share (Annual) | | Δ ≤5 Yr Debt Share (Annual) | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Δ Financial Score (Annual) | 0.0128* | 0.0134* | -0.0499*** | -0.0522*** | -0.0656** | -0.0739*** | -0.0591* | -0.0678** |
| | (0.00711) | (0.00718) | (0.0171) | (0.0177) | (0.0269) | (0.0270) | (0.0341) | (0.0341) |
| $R^2$ | 0.067 | 0.143 | 0.046 | 0.078 | 0.046 | 0.134 | 0.053 | 0.144 |
| Year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| State FE | | ✓ | | ✓ | | ✓ | | ✓ |
| Observations | 735 | 735 | 735 | 735 | 735 | 735 | 735 | 735 |

Table 4: Annual Changes in Duration, ST Debt Share vs. Financial Score

*Notes:* The table displays the estimates for least square specifications of the following form: $\Delta Y_{it,t-1} = \gamma_t + \gamma_i + \gamma \Delta \text{Financial Score}_{it,t-1} + \epsilon_{it}$. *,**, *** indicates significance at the 0.1, 0.05, 0.01 level, respectively. Standard errors are robust to heteroskedasticity.

## 4.3 State Market Conditions

In section 4.1 I examined the relationship between the macroeconomic market condition and state governments' debt maturity structure. While the macroeconomic market condition are identical for all municipal issuers, the market conditions that an individual state faces show substantial variation. To capture state specific market conditions, I compute credit spreads as outlined in Section 2.1.

I estimate the association between the market conditions in the secondary market and state governments' debt structure. Concretely, I use a specification with year fixed effects to absorb market conditions that are common to all state issuers. This includes the level of interest rates, the slope of the yield curve, as well as, the risk premium in the market, among other factors. I further include state-fixed effects to absorb time invariant state characteristics. That is, I identify the coefficient from time variant variation in both the credit spread and the measure of state governments debt structure.

I find a negative relationship between the state's credit spread and the duration of its debt portfolio. Concretely, for an increase in the credit spread of one percent I find that the duration declines by around 4.4% as shown in column 1 of Table 5. I further find consistent results when measuring the debt maturity structure with the debt share of the state in several maturity buckets as shown in columns 2-4. However, while the result is qualitatively consistent the effect is imprecisely estimated. An alternative explanation is that most of the effect that I capture via the duration measure is driven by longer maturity securities that are not captured by the debt share measures.

The results are consistent with the negative relationship between fiscal fundamentals and the duration of the debt portfolio as discussed in Section 4.2. Regardless whether I measure the fiscal strength of the issuer by its fundamentals or the market assessment, as measured by the issuer's credit spread, I find that a weaker financial position is associated with a shorter duration of the government's debt portfolio.

| | ln Duration (yrs) | Share $\leq 1yr$ | Share $\leq 3yrs$ | Share $\leq 5yrs$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| State Credit Spread | -0.0439* | 0.210 | 0.462 | 0.495 |
| | (0.0255) | (0.305) | (0.653) | (0.957) |
| $R^2$ | 0.840 | 0.734 | 0.800 | 0.809 |
| State FE | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 403 | 403 | 403 | 403 |

Table 5: Credit Spreads and Debt Maturity Structure

*Notes:* The table displays the estimation results for several specifications that test the association between the innovations in the short-term federal debt share and the maturity structure of state governments' debt structure. Standard errors are robust to heteroskedasticity and clustered at the year level. *, **, *** indicates significance at the 0.1, 0.05, 0.01 level, respectively.

## 4.4 Puerto Rico Case Study

Puerto Rico filed for bankruptcy protection under Title III of the Economic Stability Act (PROMESA) in May 2017.[15] As of writing Puerto Rico constitutes the largest municipal bankruptcy in U.S. history.[16] Puerto Rico's exited bankruptcy in March 2022, five years after its initial bankruptcy announcement (AP, 2023). The debt restructuring plan cuts Puerto Rico's government debt from $33 billion to just over $7.4 billion, reducing interest cost from 25 cents to 7 cents out of every dollar of tax revenues.[17] At the time of writing, the debt restructuring of the Puerto Rico's Electric Power Authority remains unresolved.

I examine the case study of Puerto Rico to understand the dynamics of the debt maturity structure around the bankruptcy filing. Figure 6 shows that the debt duration had declined significantly before the bankruptcy filing in 2017, and so did the fraction of debt due within the 1 year, 3 years and 5 years. After the bankruptcy filing in 2017 interest payments were stopped and Puerto Rico went into bankruptcy protection.

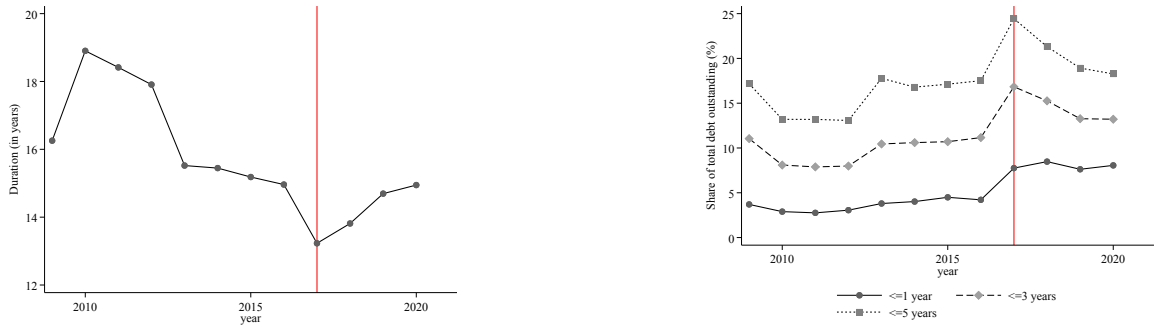
The results in Puerto Rico corroborate the findings in Section 4.2, which shows that a deterioration in fiscal fundamentals is associated with a shortening in the debt maturity

[15]Puerto Rico remains legally barred from using Chapter 9, the bankruptcy code usually taken by insolvent local governments. Title III of the Promesa law contains certain Chapter 9 bankruptcy provisions but also recognizes that, unlike the cities and counties that use Chapter 9, Puerto Rico is not part of any state. PROMESA established a Financial Oversight and Management Board, a comprehensive process for restructuring Puerto Rico's debt and expedited procedures for approving critical infrastructure projects.

[16]For a list of all general government bankruptcies since 2000 see Duffy and Giesecke (2023b).

[17]Puerto Rico has not released financial statements for 2021 and 2022 yet. Thus, the result of the debt restructuring on the total balance sheet remains unclear.

structure and higher shares of the debt maturity portfolio in shorter maturity buckets. The acceleration and reversal of the debt duration around the year of the bankruptcy filing makes the association fiscal fundamentals and debt maturity structure particularly salient.




(a) Debt Duration

(b) Share of Debt Maturity

Figure 6: Puerto Rico Debt Composition

*Notes:* The figure shows the duration of the debt portfolio in Panel (a) and the the share of debt in each maturity bucket in Panel (b). The red line indicate the timing of the bankruptcy filing in Puerto Rico.

## 4.5 Rating Re-Calibration Fundamentals

Moody's aligned their municipal finance rating scale to their global rating scale in 2010 (Adelino, Cunha, and Ferreira, 2017). As a result several state and local governments experienced a rating increase by 1 to 3 notches. In the municipal context, Adelino, Cunha, and Ferreira (2017) finds that the quasi-exogenous rating improvement led local government to increase expenditures. Furthermore, Cornaggia, Cornaggia, and Israelsen (2018) finds that Moody's recalibration led to abnormal returns in the secondary market. Concretely, after an improvement of the credit rating as result of the recalibration, municipalities experienced positive excess returns.

I study the effect of this exogenous change in ratings on the debt maturity structure of state governments.[18] I construct two different exposure variables to assess how much individual state governments are impacted by this ratings recalibration. The first exposure variable measures the proportion of bond issues by the state which experience a rating

[18]I obtain data outlining these changes in ratings for 3,862 individual bond issues of the 50 states, plus Puerto Rico and DC. In order to be included in this sample, the bond issue must be guaranteed by the government in question.

upgrade ("Rating Recalibration Proportion"). The second captures the magnitude of the rating recalibration for each state ("Rating Recalibration Size"). In this case, each issuance is assessed, from 0 to 1, based on how much a state's score was upgraded.[19] This value is then averaged across all of a state's issuances to create a score for the state. The summary statistics for these two variables are displayed in Table 6.

| | Mean | SD | p25 | p50 | p75 | N |
|---|---|---|---|---|---|---|
| Ratings Recalibration Proportion | 0.736 | 0.431 | 0.240 | 1.000 | 1.000 | 52 |
| Ratings Recalibration Size | 0.291 | 0.218 | 0.080 | 0.333 | 0.333 | 52 |

Table 6: Summary Statistics - 2010 Rating Recalibration Exposure Variables

*Notes:* Both measures of exposure are on a scale from 0 to 1. The sample comprises all 50 states, plus Puerto Rico and DC. A state whose ratings were unaffected by the recalibration receives a score of 0.)

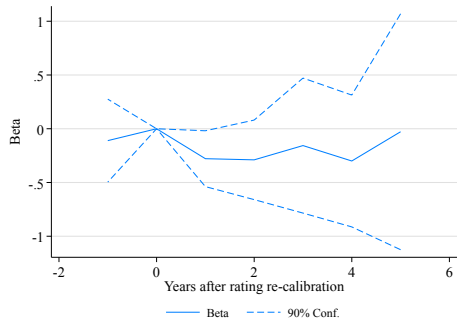
I use these two exposure variables to estimate the effect of the rating change on the debt maturity structure of state governments. Concretely, I estimate the local projection (Jordà, 2005) of changes in the duration using the year of the rating change, 2010, as base year. The hypothesis that I test is whether a positive rating change and an associated relaxation of the credit constraints leads to changes in the debt maturity structure.

The estimates suggest that there is not a statistically significant change in the composition of state governments' debt. Duration, as well as, the 1 year share, 3 year share, and 5 year change remain little affected by the rating recalibration. In addition, I test whether the recalibration had an effect on the overall outstanding liabilities. I do not find a statistically significant effect for this either. Figure 7, Panel (a) and (b) display the estimated projection coefficients for the duration of state governments' debt structure; Panel (c) and (d) show the coefficients for the liability growth rate.

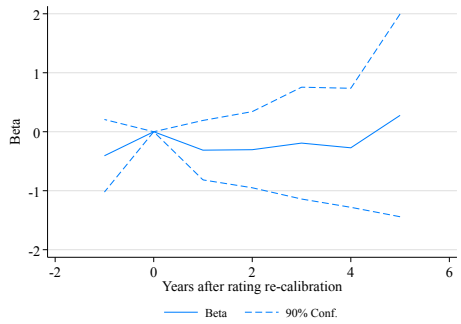
Several reasons might be responsible for the observed inertia of the debt structure. First, state governments are typically covered by multiple rating agencies simultaneously. Thus, the rating calibration—which was announced in advance—may have limited impact on investors' perception or investment mandates. Second, state governments are much bigger economic entities than municipal governments. As a result, investment analysts may monitor the underlying fundamentals more closely and were not caught off-guard when

[19]So a recalibration in rating by 3 places would receive a score of 1, an increase of 2 would get a score of .667, etc.

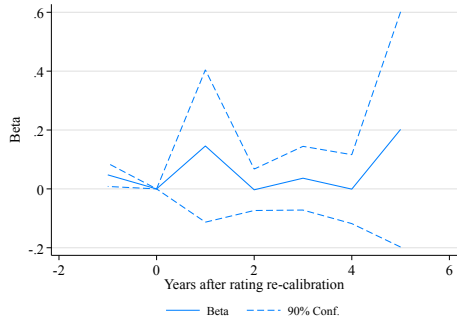
the rating recalibration occurred.



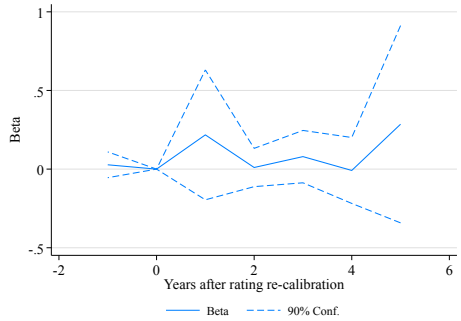

(a) Ratings Recalibration Proportion and Changes in Duration, 2009-2015




(b) Rating Recalibration Size and Changes in Duration, 2009-2015




(c) Rating Recalibration Proportion and Debt Growth, 2009-2015




(d) Ratings Recalibration Size and Debt Growth, 2009-2015

Figure 7: Betas on Rating Recalibration Exposure Variables vs Changes in Duration, Debt Growth

*Notes:* Figure (a) displays the betas on the ratings recalibration proportion variable regressed on changes in duration relative to 2010. Figure (b) displays the beta for the ratings recalibration size variable regressed on the same outcome. Figure (c) and (d) similarly use ratings recalibration proportion and ratings recalibration size, respectively, albeit regressed on liability growth relative to 2010.

## 4.6 Quantitative Easing and Federal Debt Supply

This section tests for the "fill-the-gap" hypothesis of municipal debt as a response to the large shifts in the federal government debt structure. The hypothesis was initially developed in the context of corporate debt by Greenwood, Hanson, and Stein (2010) but may be applicable to the debt of state governments since state debt is potentially considered a close substitute to federal debt. The main idea is that state governments can potentially

price their debt advantageously by issuing debt for those maturity buckets from which the federal governments substitutes away.

The empirical test of this hypothesis comes with several challenges. One of these challenges is to define how to measure shifts in the federal debt structure. First, I define the share of short-term federal debt as the share of face value of securities with a maturity of less or equal 10 years as of the total marketable federal debt. I then estimate an AR(1) model and isolate the innovations after taking into account the auto-regressive component. The raw share and the innovation series are plotted in Figure 8.[20] During the sample period I have several notable events which are captured by positive innovations that I obtain from the AR(1) model. Concretely, the quantitative easing programs from the federal reserve in 2009/2010 and 2012-2014 are clearly visible. Furthermore, I see a substantial spike in 2020 with coincides with the interventions by the Federal Reserve during Covid-19.

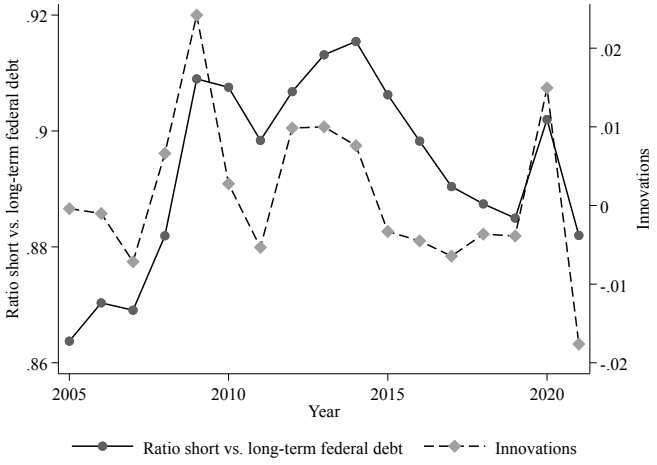



Figure 8: Share of Short-Term Federal Debt

*Notes:* The figure shows the share of short-term debt on the left-axis and the series of the innovations on the right-axis.

The isolation of the innovations in the short-term federal debt share allows me to test for any association with the changes in the maturity structure of state governments' debt structure. Table 7 displays the results. Column 1 shows that an increase in the short-term federal debt share is negatively associated with with duration, albeit not statistically significantly so. This estimate suggests that an increase in the short-term debt is concur-

[20] I follow the construction of Hilscher, Raviv, and Reis (2022) by drawing on the CRSP Treasury Bond Securities and the U.S. Treasury Monthly Statement of the Public Debt.

rently associated with a decrease in overall state government debt duration. This is the opposite from what the "fill-the-gap" hypothesis suggests. In column 2, I add additional controls as some of the macroeconomic factors affect the duration independently and may potentially be correlated with the surprise in the short-term federal debt share that I have isolated. I obtain qualitatively similar results by using the share of debt in several maturity buckets—another way to measure the maturity structure of state governments—as outcome variables. With exception of column 4, I obtain positive coefficients which means that the share of debt in these relatively short maturity buckets increases with an increase in the short-term share of federal debt.

There are several reasons why I find empirical results that stand in contrast with what the "fill-the-gap" hypothesis suggests. First, the magnitude of state government debt is a relative small fraction of overall debt outstanding; second, state government debt may not constitute the marginal liability for substitution for traditional investors into the U.S. treasury market. The peak of outstanding state government debt was $ 1.2 trn during the sample period. This compares to a total of $ 4.0 trn. of municipal securities and about $ 15.4 trn. of corporate fixed income securities (Flow of Funds, 2023). The U.S. treasury market is known for its liquidity and the ability to pledge its security as collateral, while the municipal bond market tends to be much more illiquid and characterized by a buy-and-hold behavior. Thus, it is unclear whether investors with liquidity preferences and necessity to pledge the security as collateral consider state government debt a feasible alternative.

| | Δ ln Duration | | Δ Share $\leq 1yr$ | | Δ Share $\leq 3yr$ | | Δ Share $\leq 5yr$ | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Surprise short-term ratio | -3.453 | -4.702 | 7.936 | -4.702 | 4.657 | 19.49 | 2.901 | 21.41 |
| | (3.027) | (3.361) | (12.15) | (3.361) | (14.98) | (16.76) | (17.88) | (19.91) |
| 2-yr ZC treasury yield | | 0.171 | | 0.171 | | -1.041* | | -1.434* |
| | | (0.122) | | (0.122) | | (0.587) | | (0.742) |
| 5-yr muni credit spread | | -0.435 | | -0.435 | | 2.774** | | 3.760** |
| | | (0.291) | | (0.291) | | (1.349) | | (1.766) |
| 2-10yr yield spread | | -0.00900 | | -0.00900 | | -0.453 | | -0.503 |
| | | (0.0674) | | (0.0674) | | (0.316) | | (0.385) |
| $R^2$ | 0.002 | 0.020 | 0.001 | 0.020 | 0.000 | 0.009 | 0.000 | 0.011 |
| State FE | | | | | | | | |
| Observations | 620 | 620 | 620 | 620 | 620 | 620 | 620 | 620 |

Table 7: Federal and State Government Debt Interaction

*Notes:* The table displays the estimation results for several specifications that test the association between the innovations in the short-term federal debt share and the maturity structure of state governments' debt structure. Standard errors are robust to heteroskedasticity and clustered at the year level. *, **, *** indicates significance at the 0.1, 0.05, 0.01 level, respectively.

## 4.7 TCJA Implications

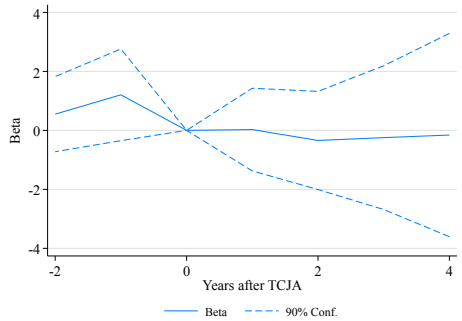
The Tax Cut and Job Act (TCJA) contains several provisions that have the potential to affect the municipal bond market materially. One of the provisions is the cap on SALT deductions, which constitutes an impairment on the ability to raise future tax revenues for states (Pevzner, Reinstein, Wynter, and Yao, 2022). Another provision is the restriction to issue tax-exempt debt in refunding operations.

The SALT tax deduction cap has shown to have substantial economic effects. Tong (2021) finds that the SALT deduction cap had a significant negative impact on home prices in high-SALT counties. Counties in which the SALT tax deduction was binding saw a reduction in growth rate in home prices by 0.79 percentage points. The most effected counties saw a reduction by 0.95 percentage points.

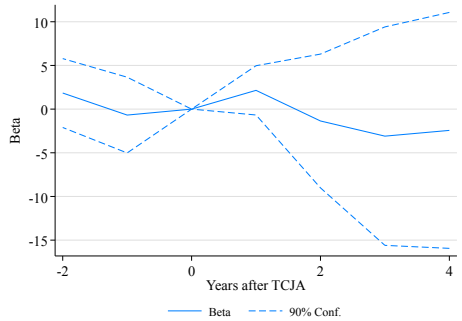
I test the effect of the SALT deduction cap on state governments' debt maturity structure by using the cross-sectional variation in exposure. I use this differential exposure to estimate the effect on the duration and shares of the debt maturity structure. Concretely, I estimate a local projection (Jordà, 2005) of changes in the duration using 2017 as base year. The hypothesis that I test is whether a higher exposure to the SALT deduction cap and thus ability to raise future tax revenues for states (Pevzner, Reinstein, Wynter, and Yao,

2022) has an impact on the choice of the debt maturity structure.

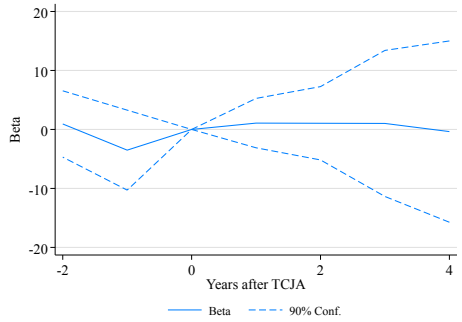
I find no differential development in the debt maturity structure as measured by duration and the shares of debt due within 1 year, 3 years, and 5 years, that is systematically related to the exposure to the SALT deduction cap as shown in Figure 9. One potential reason is that the SALT deduction cap is only binding for a small share of taxpayers. In 2017, total SALT deductions account only for 4.6% of filer income.



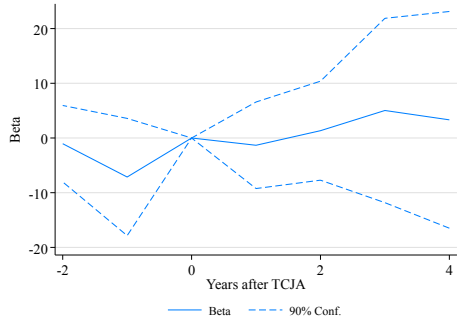

(a) SALT Exposure and Changes in Duration, 2015-2021




(b) SALT Exposure and Changes in 1 Year Debt Share, 2015-2021




(c) SALT Exposure and Changes in 3 Year Debt Share, 2015-2021




(d) SALT Exposure and Changes in 5 Year Debt Share, 2015-2021

Figure 9: Betas on SALT Exposure vs Changes in Duration, Debt Share Due in 1, 3, 5 Years

*Notes:* These figures display various outcome regressed on a variable which measures the proportion of tax returns filed in counties with average SALT deductions larger than $10,000. Figure (a) displays the betas on this SALT exposure variable regressed on changes in duration relative to 2017. Figures (b), (c), and (d) display the beta for the SALT exposure variable regressed on the changes in the proportion of debt due in 1, 3, and 5 years, respectively, relative to 2017.

# 5 Conclusion

This paper documents several novel facts about the debt composition of state governments. Revenue bonds constitute the largest single debt category of state governments, followed by general obligations for the general government. Leases account for a relative small share for both general government and for component units and business type activities. The issuer composition experiences a major shift over the sample period, which is largely attributable to the issuance of debt of the general government during the financial crisis. In contrast to the U.S. federal government debt structure, the average maturity of state government debt is significantly longer. As of 2021, the median duration is 8.6 years while 5.1 for the federal government. There is considerable heterogeneity across debt types. The average duration for general government general obligation bonds is 6.1, while the average duration for revenue bonds is longer with 8.3 for general governments and 10.4 for the component units. Leases have relatively short duration with a mean duration of 5.6 for general government leases and 5.4 for component units and business activities in 2021. Over the sample period, I observe a decrease in the mean and median of the cross-sectional duration distribution. The trajectory of the share of debt which is due within the first years mirrors the trend in duration, though with a more dominant increase for the shortest maturities in comparison to the debt maturity post 5 years.

Fiscal strength of the state government is a robust determinant of the debt maturity structure regardless whether measuring the fiscal strength via an aggregate fiscal score, credit spreads or an event study surrounding the Puerto Rico's bankruptcy announcement. A deterioration in fiscal strength is, on average, robustly associated with a decrease in the average maturity of the outstanding debt. I find that higher short-term interest rates, as well as, yield spreads are associated with longer duration and a lower share of the short-term debt maturity shares. This points towards an investor driven demand hypothesis as investors become reluctant to take on duration risk in low interest rate environments. I do not find a detectable impact on the debt maturity structure by a quasi-exogenous variation in states' credit ratings, changes in the debt maturity structure of the U.S. federal debt as induced by large scale asset purchases by the Federal Reserve, and the SALT deduction cap as part of the Tax Cut and Jobs Act (TCJA).

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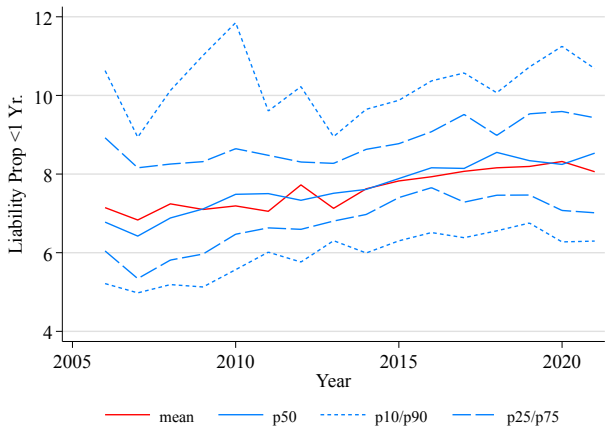
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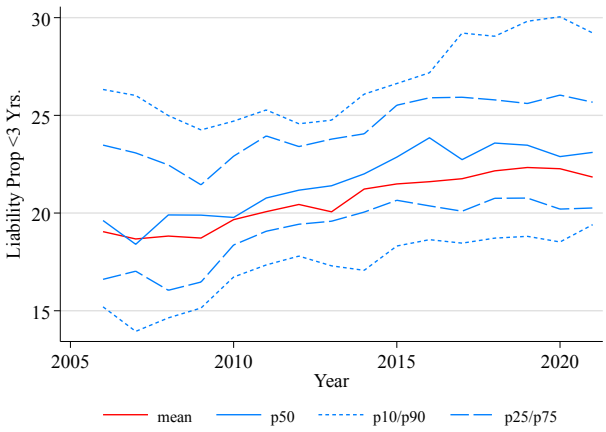
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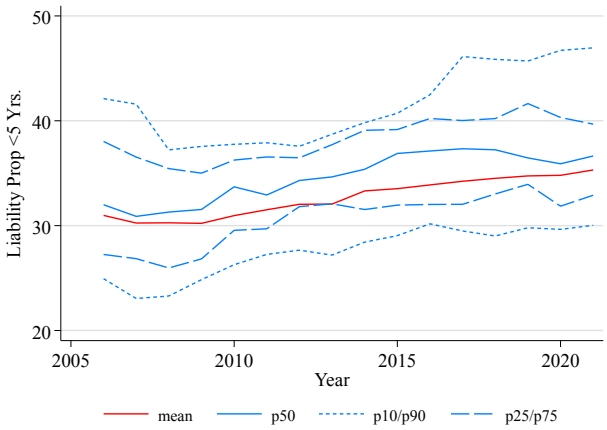
# Figures and Table




(a) Percentiles of Debt Due $\leq$ 1 Yr




(b) Percentiles of Debt Due in $\leq$ 3 Yrs




(c) Percentiles of Debt Due $\leq$ 5 Yrs

Figure A.1: Cross-Sectional Moments of Debt Shares

*Notes:* The figures visualize the mean, the 10th, the 25th, the 50th, the 75th, and the 90th percentile of the cross-sectional distributions of the share of debt due within 1 year, 3 years, and 5 years of to across the 50 states and the District of Columbia for each year of the sample.

| Share of Present Value | Mean | Median | p25 | p75 | SD | N |
|---|---|---|---|---|---|---|
| compba_go | 2.06 | 0.00 | 0.00 | 0.00 | 9.73 | 8 |
| compba_leases | 3.57 | 0.01 | 0.00 | 1.52 | 14.25 | 26 |
| compba_other | 19.17 | 2.68 | 0.00 | 29.26 | 27.68 | 33 |
| compba_revenue | 13.65 | 0.04 | 0.00 | 17.86 | 22.27 | 27 |
| ggov_go | 19.26 | 5.94 | 0.00 | 37.30 | 23.41 | 32 |
| ggov_leases | 6.32 | 2.39 | 1.22 | 5.14 | 16.76 | 48 |
| ggov_other | 16.35 | 6.88 | 0.38 | 20.77 | 22.74 | 40 |
| ggov_revenue | 11.99 | 0.50 | 0.00 | 19.46 | 17.96 | 28 |
| other | 7.62 | 0.30 | 0.00 | 3.16 | 19.90 | 32 |
| total | 100.00 | 100.00 | 100.00 | 100.00 | 0.00 | 52 |

Table A.1: Summary Statistics - 2020 Debt Composition by Debt Type

*Notes:* The values in the table are expressed in percentages (%), except for the 'N' column, which represents the number of non-missing data.

| Duration | Mean | Median | p25 | p75 | SD | N |
|---|---|---|---|---|---|---|
| compba_go | 6.31 | 6.31 | 5.36 | 7.01 | 1.84 | 8 |
| compba_leases | 7.09 | 6.50 | 4.81 | 7.65 | 4.68 | 26 |
| compba_other | 9.21 | 9.90 | 6.56 | 10.92 | 3.79 | 33 |
| compba_revenue | 11.41 | 10.51 | 9.56 | 11.73 | 3.63 | 27 |
| ggov_go | 6.40 | 6.47 | 5.59 | 7.47 | 2.01 | 32 |
| ggov_leases | 5.46 | 5.43 | 4.00 | 6.79 | 1.79 | 48 |
| ggov_other | 7.94 | 7.48 | 5.84 | 9.09 | 3.46 | 40 |
| ggov_revenue | 7.91 | 7.99 | 6.24 | 10.13 | 3.04 | 28 |
| other | 8.88 | 8.68 | 6.34 | 10.77 | 4.29 | 31 |
| total | 8.75 | 8.78 | 7.73 | 9.77 | 2.19 | 52 |

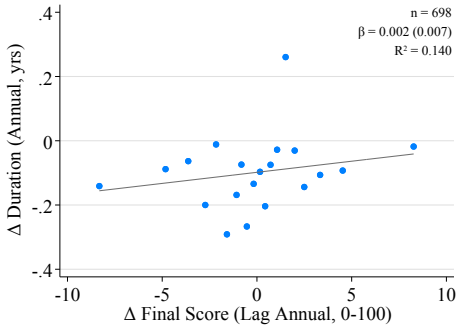
Table A.2: Summary Statistics - 2020 Debt Maturity by Debt Type

*Notes:* The values in the table are expressed in the number of years, except for the 'N' column, which represents the number of non-missing data.

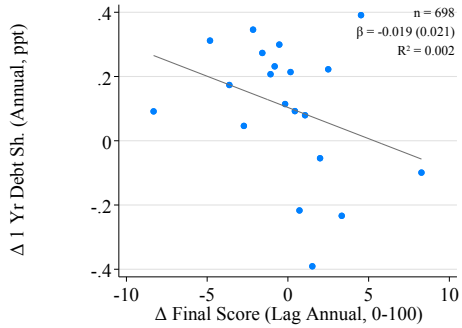
| year | p10 | p25 | p50 | p75 | p90 |
|---|---|---|---|---|---|
| 2006 | 7.28 | 8.47 | 9.96 | 10.79 | 12.03 |
| 2007 | 7.43 | 8.74 | 10.19 | 11.21 | 12.56 |
| 2008 | 8.26 | 8.95 | 10.06 | 11.26 | 12.69 |
| 2009 | 8.06 | 8.87 | 9.92 | 11.37 | 12.62 |
| 2010 | 8.07 | 8.71 | 9.62 | 10.77 | 11.95 |
| 2011 | 8.17 | 8.58 | 9.39 | 10.60 | 11.66 |
| 2012 | 7.93 | 8.61 | 9.14 | 9.96 | 11.84 |
| 2013 | 7.63 | 8.19 | 9.00 | 10.09 | 11.44 |
| 2014 | 7.60 | 8.04 | 8.84 | 10.01 | 11.63 |
| 2015 | 7.28 | 7.80 | 8.59 | 9.64 | 11.70 |
| 2016 | 7.18 | 7.84 | 8.51 | 9.44 | 12.33 |
| 2017 | 7.04 | 7.86 | 8.47 | 9.79 | 11.50 |
| 2018 | 6.69 | 7.75 | 8.54 | 9.58 | 11.44 |
| 2019 | 7.08 | 7.79 | 8.59 | 9.64 | 11.74 |
| 2020 | 6.91 | 7.73 | 8.78 | 9.77 | 11.31 |
| 2021 | 6.84 | 7.78 | 8.62 | 10.01 | 11.17 |

Table A.3: Cross-sectional Moments of the Duration Distribution

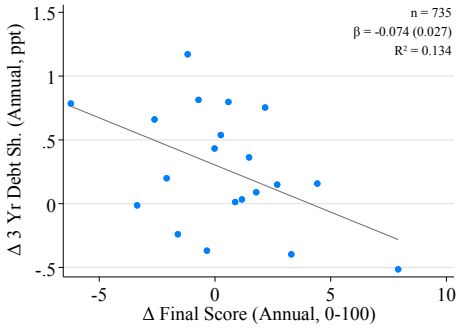
*Notes:* The tables tabulates the cross-sectional moments of the duration distribution for each year of the sample. Duration refers to the overall government debt portfolio.



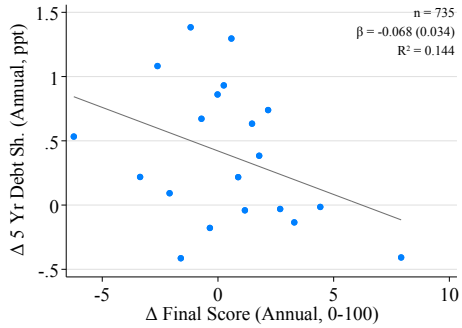

(a) Δ Duration vs. Δ Lagged Financial Score, Annual




(b) Δ ≤1 Yr Debt Share vs. Δ Lagged Financial Score, Annual



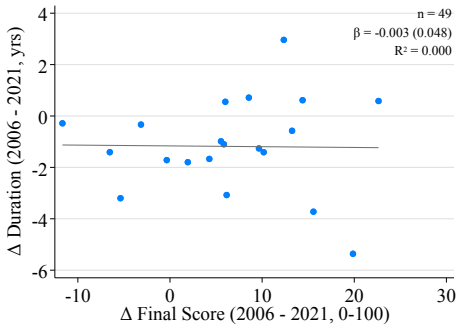

(c) Δ ≤3 Yr Debt Share vs. Δ Lagged Financial Score, Annual



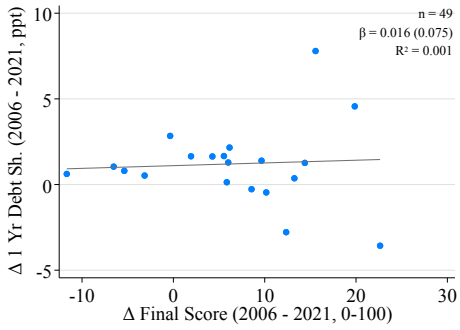

(d) Δ ≤5 Yr Debt Share vs. Δ Lagged Financial Score, Annual

Figure A.2: Short Term Changes (Annual) in Duration, ST Debt Proportion vs. Lagged Financial Score

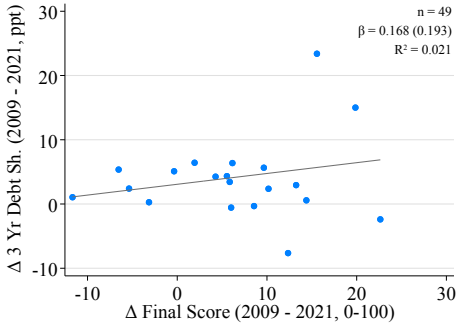
*Notes:* The figure shows the relationship between the changes of four measures of debt maturity structure and the lagged annual change of the financial strength score to mitigate endogeneity concerns. All figures shows the bivariate relationship between the score and the outcome variable after residualizing state and year fixed effect. The relationship is presented via binscatters with 20 bins. The sample encompasses all states in the United States between 2012 and 2021. More details about the data can be found in Section 2.



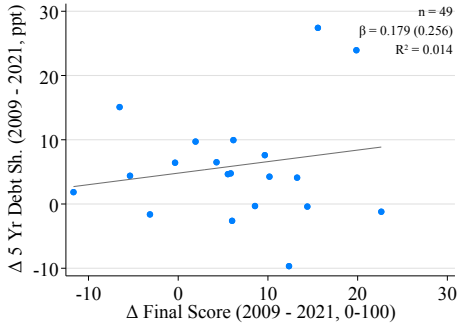

(a) Δ Duration vs. Δ Financial Score, 2006-2021




(b) Δ ≤1 Yr Debt Share vs. Δ Financial Score, 2006-2021



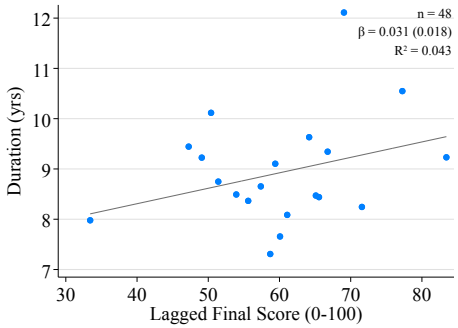

(c) Δ ≤3 Yr Debt Share vs. Δ Financial Score, 2006-2021



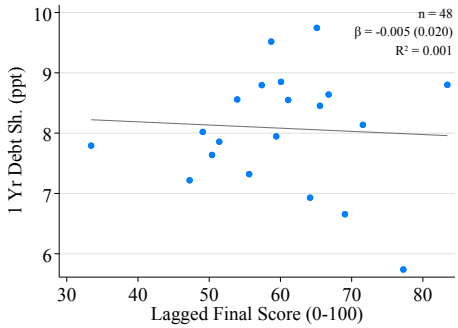

(d) Δ ≤5 Yr Debt Share vs. Δ Financial Score, 2006-2021

Figure A.3: Long Term Changes (2006-2021) in Duration, ST Debt Proportion vs. Financial Score

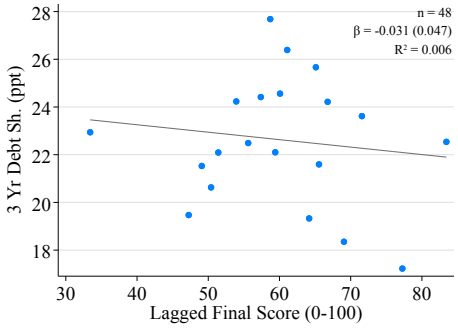
*Notes:* The figure shows the relationship between the change in the four measures of debt maturity structure and the financial strength score between 2006 and 2021. All figures shows the bivariate relationship between the score and the outcome variable. The relationship is presented via binscatters with 20 bins. The sample encompasses all states in the United States. More details about the data can be found in Section 2.



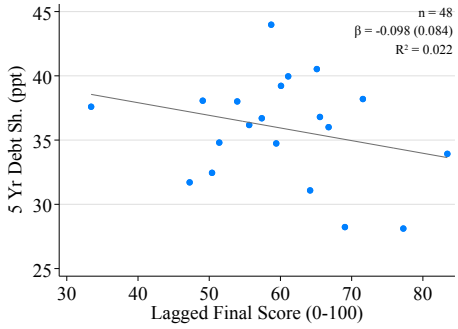

(a) Duration vs. Lagged Financial Score, 2021




(b) ≤1 Yr Debt Share vs. Lagged Financial Score, 2021




(c) ≤3 Yr Debt Share vs. Lagged Financial Score, 2021




(d) ≤5 Yr Debt Share vs. Lagged Financial Score, 2021

Figure A.4: Duration, ST Debt Proportion vs. Lagged Financial Score, 2021

*Notes:* The figure shows the relationship between the four measures of debt maturity structure in 2021 and the financial strength score in 2020. I used the lagged financial strength score as robustness to the endogeneity concerns. All figures shows the bivariate relationship between the score and the outcome variable.The relationship is presented via binscatters with 20 bins. The sample encompasses all states in the United States. More details about the data can be found in Section 2.

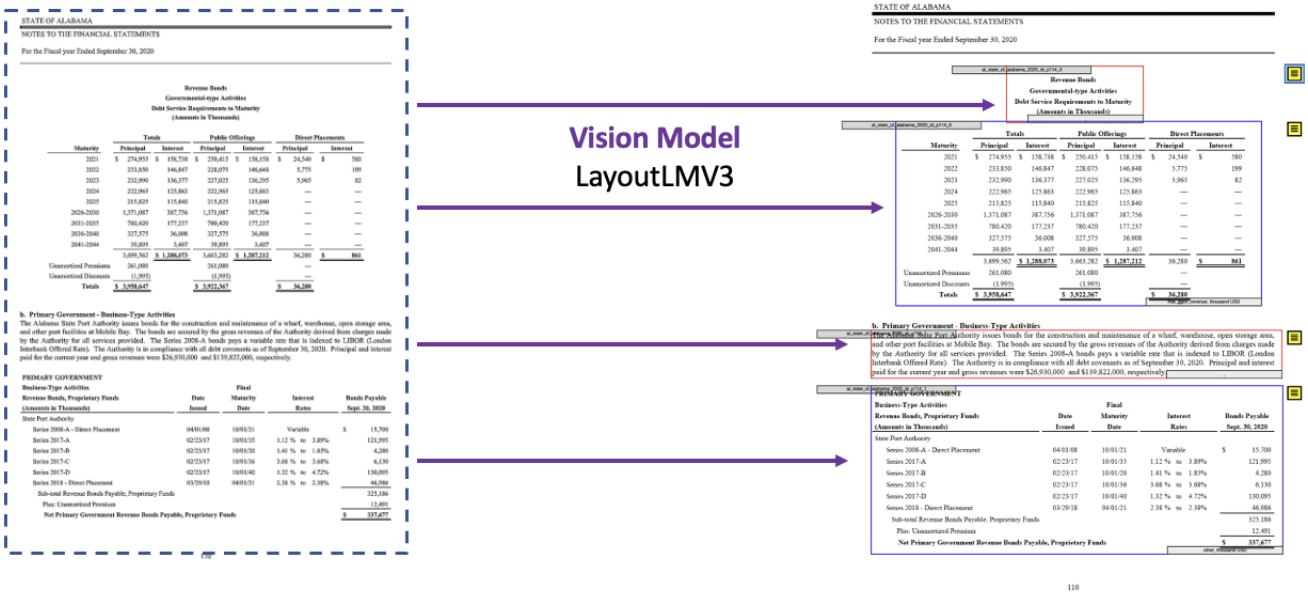



Figure A.5: Extraction Vision Model

*Notes:* I manually label approximately 1,500 pages to train a state-of-the-art vision model. The vision model uses text and layout information (multi-modal) to recognize and classify tables and titles (accuracy >99.9%)

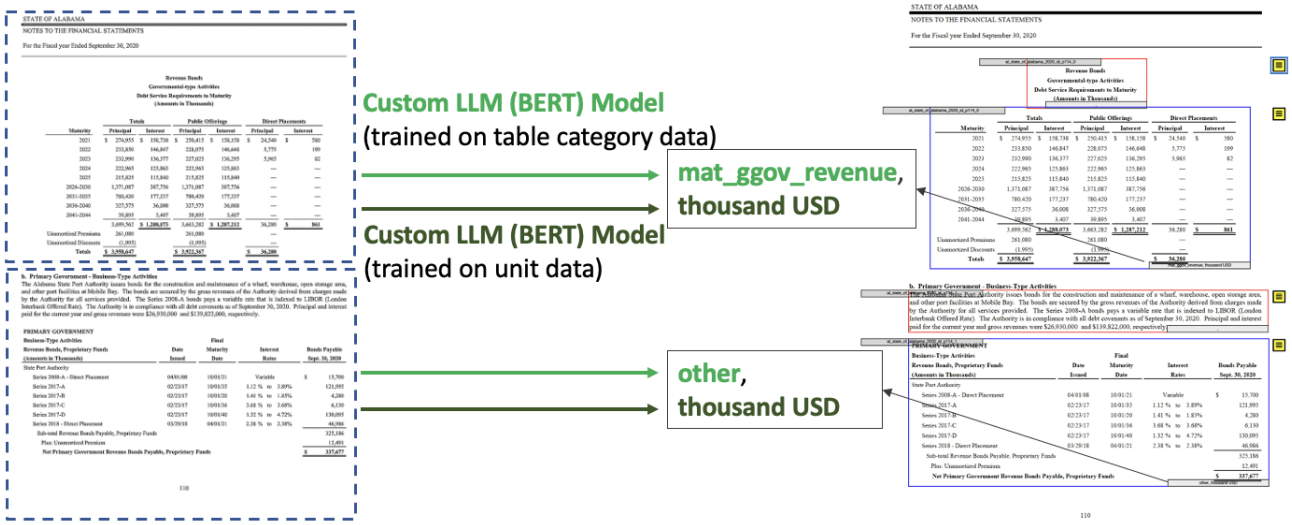



Figure A.6: Categorization via LLM

*Notes:* I manually label approximately 1,500 pages to train two models; one for the table category and another for the table unit. Language model uses table and title information to predict the table category and the table unit (accuracy >99.5%).

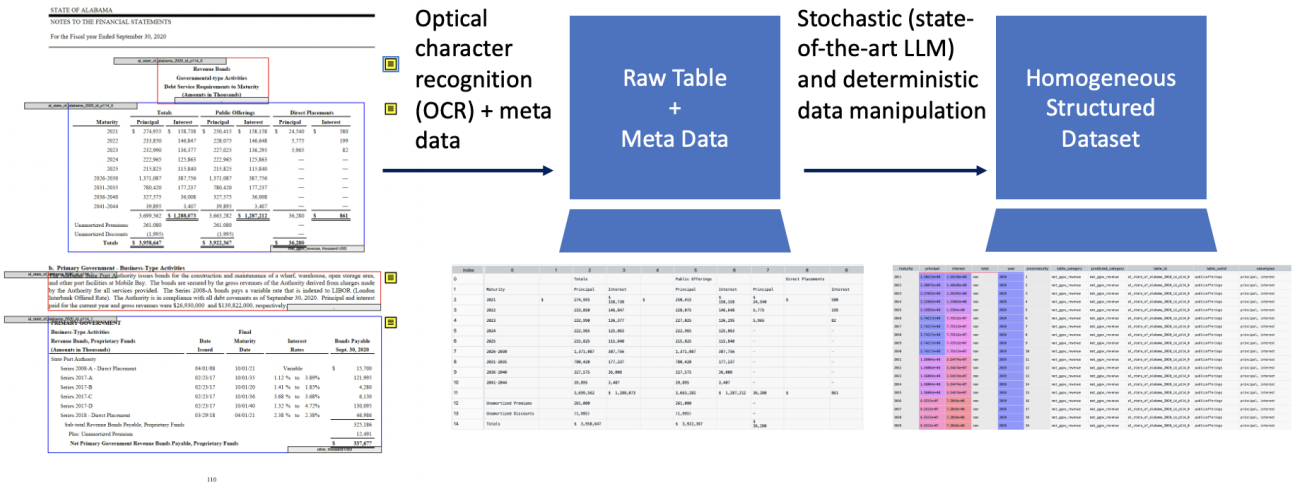



Figure A.7: Post-processing

*Notes:* The figure shows the main two steps of the post-processing. The first step uses optional character recognition to extract the highlighted table and title in the document. The second step uses a state-of-the-art large language model (LLM) and deterministic data manipulation methods to harmonize the table format.