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ABSTRACT

This study analyzes the impact of a local state's systematic risk exposure on tax-adjusted municipal bond yields in the United States. We generate a proxy for the area's systematic exposure, which we refer to as the state beta, and examine its effect on yields with various controls for corporate bond factors, remaining maturities, states, and macroeconomic conditions. We find that the state beta demonstrates a statistically significant effect on yield primarily in medium to long remaining maturity bonds. However, we find evidence that the systematic exposure of the state is likely non-time varying as seen by a reduced effect after controlling for state-fixed effects.

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Disclosures

No text in this thesis has been generated or suggested using AI. We have used Chat GPT 4.0 to improve the text and to suggest grammatical or spelling corrections. We used our discretion to accept or reject any of the suggestions. Additionally, we have used Chat GPT 4.0 to improve part of the code in the computer programs used to conduct the research reported in this thesis.

The code for data cleaning and analysis is available upon request, please contact the authors directly.

Contents

1 Introduction

Our research seeks to clarify whether the systematic correlation between states and the national economy in the United States (US) can explain the variation in general obligation municipal bond yields. By exploring this relationship, we aim to understand if and to what extent systematic risk affects local municipal bond markets differently.

General obligation municipal bonds are reliable debt securities which offer low default rates since they are fully supported by the issuing municipality (U.S. Securities and Exchange Commission, n.d.). These securities are issued to investors by local governments to raise public funds and can provide investors with a low-risk return as they offer significant tax benefits (U.S. Securities and Exchange Commission, n.d.). The US leads as the most dominant municipal bond market globally with $4.1 trillion in debt as of the beginning of 2024 (Securities Industry and Financial Markets Association, 2024). Therefore, understanding the relationship between the systematic exposure of the local area's and national bond yields has practical implications for a broad range of stakeholders in financial markets.

Previous literature identifies default risk and liquidity as two of many determinants of municipal bond yields (Schwert, 2017). Interestingly, Tuzel and Zhang (2017) demonstrates that local risk has a significant effect on local factor prices such as wages and real estate prices. This leads us to ask a critical question: How does the systematic exposure of an area, as proxied by its state's exposure, affect municipal bond yields, and to what extent?

In 2020 during the COVID-19 pandemic, we observed that the Fed announced repurchases of treasuries, mortgage-backed securities (MBS), and corporate bond ETFs in order to save the US economy (Rangvid, 2020). Consequently, there may be different effects of underlying systematic exposure during varying macroeconomic periods, especially during periods of high economic stress. Therefore, this study further contributes to the understanding of municipal bonds and can help stakeholders make informed decisions regarding investment strategies and risk management.

To start our research, we analyze panel data on municipal bond transactions, systematic correlation proxies, and corporate bond risk factors from 2005-2022. We generate a proxy for the systematic risk exposure of a state using the correlation of home prices to a national index, which we call the state beta. The primary source of tax revenue for most municipalities in the US come from real estate taxes (National Association of State Retirement Administrators, 2024). Therefore, the fluctuations in home prices are likely reflective of the local area's systematic exposure to the national economy. Using this proxy for systematic risk, we then examine whether municipalities of states with higher exposure have higher bond yields to compensate investors for the systematic exposure to default risks.

We find that the state beta has a significant effect on the municipal bond yield, with a one-unit increase in the state beta being associated with an increase in the yield by approximately 40 basis points (bps) which is statistically significant from 0 at the 99% level. Examining these results further, we find that the effect primarily comes from bonds with medium to long maturities, which are likely subject to higher default and systematic risk. Specifically, a one unit increase in the state beta is associated with a 50 basis point increase in the yields of bonds with maturities between 5-15, and 15-25 years relative to shorter maturity bonds. However, we find that much of the effect of state beta on yields is due to the non-time varying component as the inclusion of state-level fixed effects partially reduces the statistical significance of our baseline regressions, and the state-level fixed effects explaining roughly 44% of the variation in state betas. Despite this reduction, we still observe a significant correlation between state betas and yields for the longer maturity bonds, though with a reduced statistical significance.

We find that although there is limited within-state time series variation in the state beta, the cross-sectional variation exhibits a significant effect for the medium to long maturity bonds. The intuition for this result is that these bonds are more likely to face default risk that is more exposed to systematic risks and changing macroeconomic circumstances. The effect of a one-unit increase in the state beta is an increase in yield by approximately 20-25% relative to the mean. In contrast, we do not observe a material effect for the baseline state beta, which represents shorter maturities. This result is likely due to shorter maturity bonds being highly unlikely for their underlying municipalities to default within a short time horizon. However, more generally, we note that the systematic correlation of the municipalities with the national economy contribute positively to the explanation of municipal bond yields, along with the traditional bond factors and maturity effects.

2 Literature Review

To start our analysis, we discuss the previous literature on the determinants of bond prices, returns, and yields to set the stage for further analysis into the systematic exposure and their impact on yield.

2.1 Common Risk Factors in the Returns on Stocks and Bonds

A variety of market factors affect the returns of stocks and bonds making them hard to predict. As Fama and French (1993) build on the findings of Fama and French (1992), they assume markets are integrated and conclude that the average returns in stocks and bonds can be explained by five common risk factors. For the stock market, they find that a market factor, firm size, and book-to-market equity are significant determinants. Similarly, for the bond market they find that the most important factors are term-structure factors such as maturity and default risk. Upon investigation of the bond market, they split the sample of excess returns into two and five portfolios of government and corporate bonds, respectively. They form the portfolios of government bonds based solely on maturity, while corporate bonds are based on both maturity and Moody's credit ratings. Fama and French (1993) find that the term-structure factors have great explanatory power in the average bond returns and the variation in them. This holds true for highly rated bonds as supported by an R^2 and slope coefficients close to one, leaving low residuals. Therefore, we expect these factors to be statistically significant in explaining the variation in municipal bond yields in our research. Additionally, we expect related risk factors that measure the same dimension of risk to demonstrate statistical significance although the composition of the factors may differ.

2.2 The Corporate Bond Factor Zoo

Dickerson et al. (2023) argue that there are discrepancies and uncertainty in risk premiums which affects corporate bond pricing. Therefore, to investigate this they employ a broad set of 49 bond risk factors and apply them to 563 trillion models. They find that the Bayesian model averaging–SDF is more suitable than the previously used models in capturing risk premiums when simultaneously examining bond and equity factors. Dickerson et al. (2023) argue that factors such as inflation volatility risk (Kang & Pflueger, 2015), term structure yield spread

(Koijen et al., 2017), and bond index returns are the key factors in bond pricing in addition to post-earnings announcement drift.

The study of Dickerson et al. (2023) is an excellent starting point for our research. As we investigate the local systematic exposure on tax-adjusted bond yields, we directly use the traded risk factors they construct and employ them as a set of control factors in our models. This allows us to decompose the variation in the bond yield and determine the relative influence of the state beta compared with other risk factors.

2.3 The Credit Spread Puzzle

Amato and Remolona (2003) investigate the relationship between expected default losses and corporate bond credit spreads. They argue that a bond's credit quality closely relates to its bond rating, as implied from the inverse relationship they observe between the bond credit spread and its credit rating. However, it is evident that anticipated losses from default, taxes, risk, and liquidity premia are unable to completely rationalize the width of credit spreads. Amato and Remolona (2003) conclude that the wide credit spreads they observe are hard to diversify and require substantial portfolios that are unachievable in most cases.

This paper provides valuable intuition on the behavior of yields based on their quality. In contrast with their study, we investigate municipal bonds and expect to observe relatively low yields as these are highly rated and have low default rates. We apply the knowledge from Amato and Remolona (2003) and investigate whether the systematic correlation of issuing municipalities and the national US economy can contribute to an explanation of the wide credit spreads.

2.4 Municipal Bond Liquidity and Default Risk

Schwert (2017) studies the effect of default risk and liquidity on municipal bond prices. He uses three different procedures to investigate liquidity, default, and fluctuations in spreads and concludes that default risk dominates the liquidity element of the average bond spread, explaining 74-84% of it (Schwert, 2017, p. 1683). As municipal bonds have an especially low likelihood of default, he argues that the default risk plays a considerable role in pricing municipal bonds. However, it is emphasized that further research is needed in order to investigate the connection between the default risk component and municipal bond spreads.

Our paper directly builds on this study. We also focus on municipal bonds, which are tax-exempt, and therefore we employ the same method for data collection, data processing, and tax adjustment. Moreover, we build on the intuition of Schwert (2017) to determine the extent of the correlation between local systematic exposure and the pricing of municipal bonds, providing additional nuance and interpretation of his results.

2.5 Local Risk, Local Factors, and Asset Prices

Tuzel and Zhang (2017) examine whether the local risks of firms is reflected in their returns based on changes in local factor prices. They primarily focus on factors related to local wages and property. Tuzel and Zhang generate their local beta proxies as the mean industry risk exposure scaled by the overall local industry segment for metropolitan statistical areas. Further, they use this proxy in their models and examine its effects on the local firms' returns and factors. They find that the companies situated in high beta areas are more exposed to the shocks in the economies, and thus have lower returns. Additionally, they argue that fluctuations in property prices demonstrates greater risk for the corresponding companies.

The findings by Tuzel and Zhang (2017) motivate our study as we employ a similar method focusing on the role of real estate as a proxy for systematic exposure. Using local state home prices relative to a national index, we examine whether the exposure of the local economies to the national US economy has any significant effect on the tax-adjusted municipal bond yields. Additionally, we borrow the intuition from their study for the various regression specifications in our paper.

3 Data

The data description is divided into two subchapters. First, we describe the data collection and cleaning process, and then we explain the construction of the panel dataset that we utilize in our analysis.

3.1 Data Collection

3.1.1 Transaction Data

We collect transaction data for municipal bonds from the Municipal Securities Rulemaking Board (MSRB) as part of the Wharton Research Data Service (WRDS). We gather daily historical data for the period starting from 3 January 2005 to 30 June 2023 on municipal bonds for all states in the US. This is the longest sample period which allows us to identify whether the correlation between states and the national economy can explain changes in municipal bond yields before and after global crises that affected the US, such as the financial crisis in 2009 and the COVID-19 pandemic in 2020. The transaction data obtains information on the bond CUSIP, rtrs control number, trade date, dated date (issue date), maturity date, coupon, par traded, dollar price, and yield. When downloading the data from WRDS we include the following filters: the yield of the trade is not null, interest rate of the issue traded (coupon) is not null, and maturity date of the issue traded (maturity date) is not null.

We apply the cleaning process outlined by Green et al. (2010, p. 1673) and Schwert (2017, pp. 1687–1689) to the transaction data. This procedure ensures that we exclude clear errors to ensure the integrity of the data prior to any regression analysis. We first exclude any transactions that are missing information about the coupon or maturity. We then exclude trades where the dollar value of the coupon is greater than 20, the dollar price is less than 50 or greater than 150, or if the maturity is greater than 100 years or less than 1 year. Further, following Schwert (2017, p. 1687), we exclude trades recorded past the maturity date of the bond as these transactions are likely invalid. Similarly, to avoid primary market microstructure effects, we also exclude trades that occur within the first three months after issuance.

To streamline our dataset, we collapse our data to a monthly basis focusing on three key variables: yield, par traded, and dollar price. We compute monthly weighted averages for yields and dollar prices, alongside aggregating total par traded. The calculation of the monthly weighted average yield unfolds in several steps. We categorize the data by CUSIP and month, accounting for the possibility of multiple transactions for a single bond within a month. For each transaction, we calculate the product of the bond's traded par value and its yield on that date. Within each month, we then sum these products across all transactions for each CUSIP. Subsequently, this sum is divided by the total par traded for that CUSIP within the month, which is the transaction volume weighted average yield, but for short we refer to it as the yield of the bond for the remainder of the analysis. This approach effectively collapses multiple transactions for the same bond into a single, representative yield value per month, weighted by the volume of each transaction. We follow a similar calculation process for the monthly weighted average dollar price. We calculate the total par traded for each bond per month by summing the par values of all trades for each CUSIP within the month, thus reflecting the total dollar volume of each bond traded within the month. In addition, we calculate additional variables such as years since issuance, remaining maturity, and total maturity, and we express these variables in years.

3.1.2 CUSIP Data

We supplement the municipal bond transaction data with additional bond-specific data from Refinitiv Eikon to identify the state of the bond issuer. Specifically, we collect bond data on all the states from 1983 to 2024 and match this to the state of the issuer using the bond CUSIP. We apply similar filters as the bond transaction data following Green et al. (2010, p. 1673) and Schwert (2017, pp. 1687–1689) to obtain clean CUSIP data for both active and inactive general obligation bonds. Additionally, we exclude callable bonds, bonds subject to Alternative Minimum Tax (AMT), and those that are federally taxable following Schwert (2017, p. 1689). We then merge the two datasets on bond CUSIP. Our final merged CUSIP-transaction panel contains 249,605 observations with monthly frequency and obtains 52 unique "states" (including Puerto Rico and the District of Columbia). The dataset includes the bond CUSIP, the issuer name, state, ticker, issue date, maturity date, coupon, and amount outstanding.

3.1.3 Tax Data

We generate tax-adjusted yields by following the procedures and methodology of Schwert (2017). This requires collecting data on state and federal taxes, and risk-free rates. We gather yearly tax rate data from The National Bureau of Economic Research (NBER). For the state and federal tax rates, we use the state rate long gains and federal mortgage interest rate deductibility, respectively. Employing these rates, we calculate a tax adjustment factor that we then apply to our yields. This yields 969 tax adjustment factors from 2005 to 2023 which are both state and time-varying. We calculate the tax adjustment factor according to Schwert (2017, p. 1692) as follows:

$$(1-\tau_{s,t}) = (1-\tau_t^{fed})(1-\tau_{s,t}^{state}).$$

This formula allows for the federal tax rate to be time-varying but assumes it is constant across all the states in our sample. However, it also allows the state tax to vary across each state and across time.

Moreover, we proxy for the risk-free rate using 4-week treasury bill secondary market rates from FRED. This rate represents the non-seasonally adjusted annualized yields on treasure bills. The dataset has 230 observations with monthly frequency spanning from January 2005 to February 2024, and we collect monthly risk-free rates to maintain consistency with our data. The risk-free rates are fixed across all states but time varying across the sample period. Consequently, we derive our tax-adjusted yields following Schwert (2017, p. 1692) as follows:

$$y_{i,t}^{TA} - r_t = \frac{y_{i,t}}{1-\tau_{s,t}} - r_t.$$

The constructed tax-adjusted yield is the dependent variable in our primary regression specifications.

3.1.4 Housing Prices Indices

We source housing price index (HPI) data from the Federal Housing Finance Agency (FHFA). This data includes quarterly Purchase-Only Indexes estimated using sales price data. From these datasets, we collect the individual states and U.S. Summary data to access housing price indexes at the state and national levels, respectively. Both datasets include seasonally adjusted and non-adjusted data. We use the seasonally adjusted data on the national and state level. Moreover, both panel datasets have quarterly frequency with 33 years of observations, starting with the first quarter of 1991 up until the third quarter of 2023. We index the first quarter of 1991 (1991Q1) to be equal to 100.

The housing price index is a proxy for changes in housing prices in the US (Federal Housing Finance Agency, n.d.). The national HPI dataset has 131 observations of the Purchase-Only Index, Purchase-Only Index with percentage change over previous quarter, and Purchase-Only Index with percentage change over the previous four quarters. Similarly, the US States housing price index dataset contains 6,681 observations. We compute the percentage change in the HPI to obtain the state HPI returns, which we merge with the national and state housing prices datasets based on year and quarter. To remove missing observations from the data, we drop observations from the first quarter of 1991. As a result, we are left with a dataset which demonstrates the quarterly HPI returns on the state and national level from 1991 to 2023 for all states in the US. Further, in our analysis we use this data to calculate the state beta, our proxy for the correlation between a given state and the national US economy.

3.1.5 Corporate Bond Risk Factors

We collect cross-sectional bond risk factors from Dickerson et. al (2023). This panel dataset includes 14 traded corporate bond factors, which are the returns of long-short portfolios used to construct the factor.[1] The dataset contains 444 observations and includes the identification index, date, and value at the corresponding date. The data spans from 31 January 1986 until 31 December 2022 and is at a monthly frequency.

[1] Please see Dickerson et. al. (2023) Appendix B, Table A.1 Panel A, p.44 for more information regarding the exact construction of these factors.

3.2 The Aggregate Dataset

We merge the cleaned transaction and CUSIP data by the common CUSIP variable found in both datasets. This facilitates the identification of the state in which the bonds were issued. After consolidating the data into one comprehensive panel dataset, we exclude all transaction months with missing observations. Missing observations are likely due to the lack of transaction data for the bonds in the CUSIP data. Additionally, we omit observations with obvious inaccuracies such when the traded date occurs prior to the issuance date. This reduces the dataset from 1,212,301 to 1,165,970 trades, as we identify 46,331 invalid transactions. Furthermore, we follow Green et al. (2010, p. 1673) and exclude bonds with less than 10 transactions over the entire sample period as these are likely subject to stale prices and limited liquidity. This results in 874,835 remaining transactions and causes the number of unique CUSIPs to fall from 121,065 to 36,874. Next, we merge the tax-adjustment factor and risk-free rate data onto our cleaned and combined bond data. We divide all the yields by the tax adjustment factor and subtract the risk-free rate to obtain our correctly tax-adjusted yields following Schwert (2017, p. 1692). This further decreases the total transactions to 867,979. Finally, we merge the cleaned transaction data with corporate bond risk factors from Dickerson et al. (2023) and drop any missing observations, leaving 811,078 transactions in our final sample.

Following our cleaning procedure, our data contains 49 unique states. The excluded states are Wisconsin, Puerto Rico, and District of Columbia. The final sample contains 36,752 unique bonds and 811,078 transactions. We provide a breakdown of the difference in unique bonds and transactions before and after the cleaning procedure in Appendix 2, Table 1. Similar to US population demographics, we find that California and Texas make up a significant portion of our sample accounting for 18.7% and 15.7% of the transactions in our data, respectively. New York, New Jersey, Illinois, and Pennsylvania follow at 7%, 4.7%, 4.3% and 4.3%, respectively. The remaining states individually account for 0-3.5% of the transactions in the data (see Appendix 2, Table 2).

When analyzing the bond characteristics of our data, we find that the average monthly total par traded amounts to $681,140.71, although we observe a minimum of $237 and a max of $527,330,000 (see Appendix 2, Table 3). The standard deviation exceeds $3.9 million, which indicates great variability in the monthly par traded amounts. Additionally, we find that the monthly weighted average dollar price is $108.59 on average, with a relatively low standard deviation of $15.12. Moreover, the average remaining maturity for the bonds is 5.71 years, with a minimum of 1.04 years and a maximum of 37.08 years. We observe that 90% of the bonds have a remaining maturity of 9.33 years or less which indicates that only a minority of bonds have long remaining maturities. We observe that the average tax-adjusted yield is 2% with a standard deviation of 2%, indicating moderate variability in bond yields. The yields are positively skewed and range from a minimum of 0% and to a maximum of 44%. Furthermore, we observe that 90% of the tax-adjusted yields are below 4%, suggesting that only a small and insignificant portion of the bonds analyzed in our data have unusually high yields.

4 Hypothesis

We present our main hypotheses and additional hypotheses to support and expand on our fundamental research question: Does the systematic correlation between states and the national US economy explain variation in municipal bond yields?

4.1 Systematic Correlation Between State and National Economy

Hypothesis 1: There is a correlation between states and the national US economy.

$$H_0:\ \beta_{i,1} = \beta_{i,2} = \cdots = \beta_{i,N} = 0$$

$$H_a:\ \exists\ j \in \{1,2,\ldots,N\}\ \textit{such that}\ \ \beta_{i,j} \neq 0$$

$$where\ \beta_{i,j}\ = \frac{Cov(State_i\ HPI\ Return\ ,\ National\ HPI\ Return)}{Var(National\ HPI\ Return)}$$

Tuzel and Zhang (2017) demonstrates that local risk factors influence a firm's risk exposure based on its location. Consequently, we construct a correlation proxy which we refer to as the state beta. This captures the correlation between states and the national economy in the US, using HPI seasonally adjusted returns. The state beta is the key explanatory variable in our subsequent models. Rejecting the null hypothesis implies that there is a correlation between the national and state economy on average.

4.2 Systematic Correlation Effect on Yields

Hypothesis 2: The state beta has a significant effect on yield.

In our second hypothesis, we examine whether the state beta has an effect on local bond yields. To avoid the correlation between state betas and existing factors, we include as controls the corporate bond risk factors from Dickerson et. al. (2023). Additionally, we test this hypothesis by examining two scenarios: one which includes the correlation proxy state and national US economy, and one which excludes it. These pooled linear regressions determine whether the systematic correlation between states and the national economy influences bond yields and to what extent. We predict that there is a statistically significant relationship between the state beta and the yield.

4.3 Systematic Correlation Effect on Yields without State-Fixed Effects

Hypothesis 3: The state beta contributes significantly to the yield when accounting for different controls without state-fixed effects.

In this hypothesis, we test if the state beta influences the yield while fixing the variation that comes from different economic conditions and remaining maturities. In this phase, we only consider the most relevant bond risk factors to prevent overfitting the model and exclude state-fixed effects. This test indicates whether the correlation proxy explains variation in the tax-adjusted yield controlling for the additional factors. We expect to observe statistical significance for the state beta as a baseline variable or through the interaction with other variables.

4.4 Systematic Correlation Effect on Yields with State-Fixed Effects

Hypothesis 4: The state beta contributes significantly to yield when only considering state-fixed effects alongside other bond risk factors.

Our fourth hypothesis studies whether the state beta influences yield when accounting for state-fixed effects alongside bond risk factors. This specification changes the interpretation of the regression, as we now account for within-state variation in state betas and yields. We test the extent that the state beta explains bond yields with only state-fixed effects while considering all, a selected set, and none of the corporate bond factors. A failure to reject the null hypothesis means that we cannot confirm that the correlation proxy has any explanatory power, meaning it is statistically insignificant after controlling for the non-time varying effects, within states, and along with other factors in the model.

4.5 Systematic Correlation and Remaining Maturities Effects on Yields

Hypothesis 5: The state beta contributes significantly when accounting for varying remaining maturities fixed effects alongside other controls.

The fifth hypothesis examines whether the state beta's effect on yield differs across the remaining maturities of the bonds and other controls. The fifth hypothesis states that if the state beta coefficient and its interaction with remaining maturities is not statistically significant, then the correlation between states and the national economy has no effect on tax-adjusted yield after accounting for varying remaining maturities alongside state fixed effects and bond risk factors. Rejecting the null hypothesis implies that the state beta has a statistically significant effect on the tax-adjusted yield when accounting for heterogeneity of the data among states and different maturity intervals.

4.6 Systematic Correlation and Economic Conditions Effects on Yields

Hypothesis 6: The state beta contributes significantly to the yield when accounting for the economic downturns in the US alongside other controls.

Our sixth hypothesis examines whether the impact of the state beta on bond yield persists and how it changes when considering changing macroeconomic conditions in the US. The hypothesis involves two parts. First, is whether the coefficient on state beta is significant, after controlling for a general economic conditions indicator. The second is whether the state beta has significantly different predictive implications in bad times relative to good times, as indicated by the interaction of the state beta with the bad times indicator. The null hypothesis states that if the state beta coefficient and its interaction with economic conditions is insignificant, then the correlation between states and the national economy factor does not capture any variation in tax-adjusted yield in varying economic conditions after accounting for other fixed effects and risk factors. Rejecting both null hypotheses means that the systematic correlation between states and the national economy still has a statistically significant effect, but that it is different across macroeconomic regimes.

4.7 Within-State Variation in Systematic Correlation

Hypothesis 7: The state beta is state and time varying.

We run a supplementary test to determine how much of the state beta is explained by the state-fixed effects, as this provides information on the persistence of the state beta. For instance, a high R^2 will indicate that the relationship between the state-fixed effects and the state beta is mostly cross-sectional. As a result, it is highly likely that the state beta only has a limited effect on tax-adjusted yield within the time series variation of the state. Moreover, a high explanatory power will indicate that keeping the state-fixed effects as a control may not be appropriate, due to the limited statistical power if the primary variation in state beta, and yields, is cross-sectional and thus supporting hypothesis 3. This is because most of the effect in our study will be due to cross-sectional variation across states and not time series variation within states.

5 Methodology

The methodology section describes the methods we use to test our hypotheses and consists of 7 models (regression specifications).

5.1.1 Model 1: Generating State Betas

We first assess whether there is a correlation between states and the national economy in the US. The first hypothesis lays the groundwork for our analysis as we want to obtain correlation proxies which represent state and time-varying correlations between the state and national HPI returns. According to Municipal Research and Services Center of Washington (2024), a substantial portion of the cash stream to municipal bonds originates from property taxes. Therefore, housing prices are a good proxy for the state beta as we infer that the cash flows to municipal bonds are directly linked to housing prices. This resulting estimated beta plays a significant role in our research as we will employ it as an independent variable in subsequent analysis to determine whether the state beta can explain variations in bond yields after accounting for additional risk factors. To generate Model 1, we run a rolling window linear regression with state HPI return as the dependent variable and national HPI return as the independent variable:

$$R_{i,t}^{state} = \alpha_i + \beta_{i,t} \times R_t^{national} + u_t, \quad (1)$$

where $R_{i,t}^{state}$ denotes the HPI return for state *i* at time *t*, and $R_t^{national}$ is national HPI return at time *t*. This regression utilizes panel data on state and national HPI returns to estimate the correlation between states the national economy, yielding state-specific betas as proxies for correlation over time.

When constructing state betas, we face a trade-off between the width of the rolling window and the statistical power of our tests. Particularly, an increase in the width of the rolling window decreases the time-series dispersion in the state beta values. However, wider rolling windows generate more precise estimates of state betas increasing our statistical power to detect significant correlations. Therefore, to balance these trade-offs, we utilize a 5-year rolling window to obtain more variation in the state beta values while also preserving statistical significance. Consequently, this regression allows us to obtain 5-year or 20-quarter rolling state betas from 1991 to 2023. Further, to avoid overlapping observations, we omit intermediate state betas in our analysis, so that the remaining state betas represent the first quarter of the lower bound year and the fourth quarter of the upper bound year. Particularly, this means that the state beta covers the period starting from the first quarter in 1992 until the fourth quarter in 1996, the subsequent state beta covers the period starting the first quarter in 1997 until the fourth quarter of 2001, and so on.

5.1.2 Model 2: State Beta Effect on Yield

In Model 2, we use a pooled regression to understand the extent that the state beta explains variation in yields. In this model, the tax-adjusted municipal bond yield is regressed on the lagged state beta and the bond risk factors from Dickerson et. al. (2023). As a result, we construct Model 2 as follows:

$$y_{i,t}^{TA} = \beta_{i,t} * State\ Beta_{i,t-1} + \sum_{j} \omega_{j,t} * RF_{j,t} + u_t, \qquad (2)$$

where $y_{i,t}^{TA}$ represents the tax-adjusted municipal bond yield for state i at time t, $State\ Beta_{i,t-1}$ denotes the state beta derived from Model 1 for state i at lagged time $t-1$ (shifted by a year), and $RF_{j,t}$ denotes the returns of the proxy portfolios that composes the bond risk factor j at time t.

5.1.3 Model 3: State Beta Effect on Yield without State-Fixed Effects

In Model 3, we want to test how the state beta influences yield with the corporate bond factors while accounting for heterogeneity in different economic conditions and remaining maturities. In contrast to Model 2, we will only test Model 3 with a limited set of corporate bond risk factors being the bond default, duration, value, and the short-term reversal risk factors as these are the most relevant risk factors for municipal bonds. Additionally, we exclude specific risk factors based on their similarity and the correlation between them to remove potential effects from multicollinearity (see Appendix 1, Figure 2). For example, bond credit risk and bond default risk measure the same dimension of risk but the composition of the factors differs slightly, hence they are expected to be highly correlated. Therefore, we only include the risk factors most relevant to municipal bonds to prevent overfitting the model. Moreover, we introduce remaining maturities fixed effects, bad times fixed effects, and their interaction terms with state betas. These additional terms will exclude all the variation in the yield that is attributed to varying economic conditions and different maturities. As a result, we build three different versions of Model 3. The comprehensive model includes the lagged state beta, bond risk factors, economic conditions and remaining maturities fixed effects, and interaction terms with the state beta. The next two models will replicate the comprehensive model while excluding either economic conditions or remaining maturities fixed effects. This results in the following models:

$$\begin{aligned} y_{i,t}^{TA} = \beta_{i,t} * State\ Beta_{i,t-1} + \sum_{j} \omega_{j,t} * RF_{j,t} \\ + \lambda_t * Bad\ Times\ Dummy_t \\ + \psi_t * Bad\ Times\ Dummy_t * State\ Beta_{i,t-1} \\ + \sum_{t} \gamma_t * Maturity\ Dummy_t \\ + \sum_{t} \theta_t * Maturity\ Dummy_t * State\ Beta_{i,t-1} \\ + u_t, \end{aligned} \tag{3.1}$$

$$\begin{aligned} y_{i,t}^{TA} = \beta_{i,t} * State\ Beta_{i,t-1} + \sum_{j} \omega_{j,t} * RF_{j,t} \\ + \lambda_t * Bad\ Times\ Dummy_t \\ + \psi_t * Bad\ Times\ Dummy_t * State\ Beta_{i,t-1} \\ + u_t, \end{aligned} \tag{3.2}$$

$$\begin{aligned} y_{i,t}^{TA} = \beta_{i,t} * State\ Beta_{i,t-1} + \sum_{j} \omega_{j,t} * RF_{j,t} \\ + \sum_{t} \gamma_t * Maturity\ Dummy_t \\ + \sum_{t} \theta_t * Maturity\ Dummy_t * State\ Beta_{i,t-1} \\ + u_t, \end{aligned} \tag{3.3}$$

where *Bad Times Dummy$_t$* is a dummy variable that takes the value of 1 for the years 2008, 2009 and 2020, and 0 otherwise. These years are classified as bad economic years in the US as they display an annual growth in GDP below 1%, while the remaining years from 2005 to 2023 are treated as good years.[2] Moreover, *Maturity Dummy$_t$* represents the dummy variables for municipal bonds with remaining maturity between 0-5, 5-15, 15-25, and 25+ years, where the first interval is omitted from the regression as it will act as the reference remaining maturity interval in our research. The introduced interaction terms of the dummy variables with the state beta allow us to estimate the marginal effect that the state beta has on yield within the respective category. The remaining notations are the same as in the previous model. Furthermore, we follow Schwert (2017) and cluster the standard errors on the state-year level in this and subsequent regressions to take into account correlation in the residuals.

5.1.4 Model 4: State Beta Effect on Yield with State-Fixed Effects

In Model 4, we examine whether the previously estimated state betas from Model 1 capture variation in the tax-adjusted municipal bond yields while accounting for state-fixed effects alongside bond risk factors. The state-fixed effects are implemented by creating state-specific dummy variables. The introduction of state-fixed effects is potentially more suitable for our study compared to a random effects model as it will account for heterogeneity in the data and eliminate omitted variable bias from constant unobserved state-specific variables. This will allow us to directly examine the impact of the area's systematic exposure on the municipal bond yields, for the within-state time series. Moreover, we test Hypothesis 4 across variations with comprehensive, selected, and none of the bond risk factors. As in the previous specifications, the regression with limited risk factors will only include bond default, duration, value, and the short-term reversal risk factors. Consequently, we employ the state betas, bond risk factors, and state-fixed effects, which yields the following regression:

[2] We infer this from the graph of Annual growth of the real gross domestic product of the United States from 1990 to 2023 from U.S. Bureau of Economic Analysis (2024).

$$y_{i,t}^{TA} = \beta_{i,t} * State\ Beta_{i,t-1} + \sum_j \omega_{j,t} * RF_{j,t} + \sum_i \mu_i * State\ Dummy_i + u_t, \quad (4)$$

where $y_{i,t}^{TA}$ denotes the tax-adjusted municipal bond yield, *State Beta*$_{i,t-1}$ denotes the lagged correlation proxy derived from Model 1, $RF_{j,t}$ denotes the bond risk factors, and *State Dummy*$_i$ denotes the state dummy variables. The yield and state beta variables are state-specific and time-varying. However, the risk factors are time-varying but constant for all states, while the state dummy variables are state-varying but constant over time.

5.1.5 Model 5: State Beta Effect on Yield with Remaining Maturity Fixed Effects

In Model 5, we analyze whether varying bond maturities influence the state beta's impact on yield. This is the same specification as in Model 3 (Eq. 3.3) but includes state fixed effects:

$$y_{i,t}^{TA} = \beta_{i,t} * State\ Beta_{i,t-1} + \sum_j \omega_{j,t} * RF_{j,t} + \sum_t \gamma_t * Maturity\ Dummy_t + \sum_t \theta_t * Maturity\ Dummy_t * State\ Beta_{i,t-1} + \sum_i \mu_i * State\ Dummy_i + u_t, \quad (5)$$

where the definitions for all variables are the same as in previous models.

5.1.6 Model 6: State Beta Effect on Yield with Economic Conditions Fixed Effects

In Model 6, we attempt to capture the marginal effect of the state beta on yields under varying economic conditions in the US. This model is an extension of Model

5, where we include all the previous variables in addition to the bad times dummy variable and its interaction term with the state beta. Additionally, we will examine the results with all, selected and no bond risk factors. This gives us the following model:

$$
\begin{aligned}
y_{i,t}^{TA} = \beta_{i,t} * State\ Beta_{i,t-1} + \sum_j \omega_{j,t} * RF_{j,t} \\
+ \lambda_t * Bad\ Times\ Dummy_t \\
+ \psi_t * Bad\ Times\ Dummy_t * State\ Beta_{i,t-1} \\
+ \sum_t \gamma_t * Maturity\ Dummy_t \\
+ \sum_t \theta_t * Maturity\ Dummy_t * State\ Beta_{i,t-1} \\
+ \sum_i \mu_i * State\ Dummy_i + u_t,
\end{aligned} \quad (6)
$$

where all the definitions for the variables are unchanged from the previous models.

5.1.7 Model 7: Within-State Variation in State Beta

In Model 7, we run a supplementary regression to test how much state-fixed effects explain state betas. In this model, we treat state beta as a dependent variable and regress it on the state dummy variables using the following specification:

$$State\ Beta_{i,t} = \sum_i \mu_i * State\ Dummy_i + u_t, \quad (7)$$

where $State\ Beta_{i,t}$ represents the state beta value for the state i at current time t, and $State\ Dummy_i$ denotes the state dummy variables. The model allows us to test how much the state fixed effects explain the variation in state betas, with the remaining variation due to within time-series variation.

6 Results and Analysis

In this section we discuss and analyze our main findings.

6.1 Systematic Correlation Between State and National Economy

Our initial calculation of state betas generates 5,661 state betas, which vary across state and time. We find that 3,743 state betas are statistically significant at the 10% level, while the remaining 1,918 are statistically insignificant. With approximately 66% of the total output exhibiting statistical significance, we proceed and apply the generated state betas in subsequent analysis as the aim of the study is primarily to obtain the correlation proxies rather than observe their statistical significance in isolation. From this sample, we exclude intermediate state betas to avoid overlapping observations as described in section 5.1.1. Consequently, we obtain one state beta for every fifth year in our sample, leaving 1,377 state betas for further analysis.

Figure 1 in Appendix 1 demonstrates the systematic correlation of all US states with the national economy in the form of the state beta from 1992 to 2022. The results from Model 1 indicate that on average local economies do not exhibit large differences in state beta values after the dot-com crisis in 2000 (see Appendix 1, Figure 1). For the next 12 years, we find that the state betas remain relatively stable and that there is low divergence in their values across all states. Said differently, the states that demonstrate high correlation with the national US economy tend to maintain their high levels. However, it is evident that the state betas move towards long-term averages for all states. For example, California displays a high state beta value for the following 9 years after 2003, but eventually assimilate with the all-states average value which is approximately 1. The crisis in 2000 significantly affected California and specifically Silicon Valley, which was associated with the epicenter of the crisis (Pastor & Zabin, 2002). Therefore, we find it intuitive that this state would have a beta coefficient greater than 1. In comparison, we observe that Kansas obtains a state beta close to 0, which appears to be reasonable as most of the suffered headquarters were not located in Kansas during the tech bubble. The economy of Kansas is associated with oil, natural gas, and other energy sources according to Merriam et al. (2012). Therefore, we observe that Kansas maintains its low level of correlation through the years after 2003, also being close to the all-states long-term average (see Appendix 1, Figure 1).

Moreover, Figure 1 demonstrates that the dispersion of the state beta across all states increased during the period of 2014-2017. We argue that this is due to the transition period of the economies from the recession into recovery. This is supported by Brown (2017), as he discusses that each state recovers at its own rate depending on its specialization. The period of 2014-2017 is associated with high volatility in commodity prices which affects the states that are more involved in natural resource extraction such as oil and gas (Brown, 2017). This could be seen as one of the factors that significantly affected local economies' development, causing the state betas to be different across states in our results.

Furthermore, we detect that the state betas were closest to the all-state average two years before the COVID-19 pandemic in 2020. During this period, we find that majority of the states obtain a state beta close to 1, indicating that the local economies co-move with the national US economy without significant divergence across the states. The same pattern persists in the period of the COVID-19 crisis and there are no big outliers in the year 2020. Generally, the state beta of the local economies remained close to 1, thus indicating that there is no big difference in the local economies that attributed to the changes in housing price indexes. In contrast to the previous crises, the lockdowns during COVID-19 affected all the states causing the movement with the overall US economy to be one-to-one for all states which we infer from Figure 1.

6.2 Systematic Correlation Effect on Yield

Table 1 in Appendix 1 shows the regression results for Model 2. In this model, we run a pooled regression with the state beta and all bond risk factors to determine their effect on yield. We find that the state beta has a statistically significant positive effect at the 1% significance level. Therefore, a one unit increase in the state beta results in a 40 bps increase in the yield. This indicates that the state beta has a substantial effect, as it demonstrates nearly a 20% greater yield relative to the average yield of 2% (see Appendix 2, Table 3). Additionally, we observe that all bond risk factors are statistically significant at a 1% significance level (see Appendix 1, Table 1, column 1). The results from the pooled regression signify that the included variables capture 10.6% of the variation in the tax-adjusted municipal bond yield.

To further investigate the state beta's effect in the pooled regression model, we run a separate regression with all risk factors while excluding the state beta. We observe that both the R^2 and adjusted R^2 slightly decreased by 1.9% from 10.6% to 8.7% (see Appendix 1, Table 1, column 2), indicating that state betas have significant explanatory power in the variation of yields. Additionally, there is little variation in the magnitude of the bond risk factors' coefficients and their significance remain the same, indicating that there is likely little correlation between the effect of state betas and the bond risk factors. Consequently, we conclude that the state beta contributes positively to the variation in the tax-adjusted yield in Model 2 as seen in column (1). However, it is not clear if this contribution is due to time-series variation or cross-sectional variation across states, which we will explore later. Although, Model 2 supports our hypothesis that the systematic correlation factor influences yield, we keep in mind that this model may neglect important aspects that may skew our results. Therefore, we continue our investigation by refining our model to determine if the statistical significance of the state beta persists when accounting for heterogeneity among states, remaining maturities, and economic conditions.

6.3 Systematic Correlation Effect on Yield without State-Fixed Effects

Table 2 in Appendix 1 shows the regression results for Model 3. In Model 3.1, we include all the fixed effects and interaction terms related to remaining maturities and economic conditions (see Appendix 1, Table 2, column 1). The intercept is statistically significant at 1% significance level, meaning that the average yield for municipal bonds with remaining maturity of 0-5 years is 1.5% during good economic times in the US. Additionally, the selected bond risk factors demonstrate statistically significant coefficients at a 1% significance level for default, short-term reversal, and value risks, while the duration risk factor demonstrates a 10% significance level. Moreover, the result of this model demonstrates that the baseline state beta is statistically insignificant at all levels for bonds with shorter maturities during good times. However, turning to the effects of the remaining maturities for 5-15 and 15-25 years, we observe statistical significance at a 1% level. Bonds with longer maturities have significantly higher yields of 90 and 350 bps, respectively, relative to the reference maturity of 0-5 years. Additionally, we find that a one unit increase in the state beta has a positive marginal effect of 50 bps on the yield when municipal bonds are within these maturity intervals as seen through the interaction terms. This effect is statistically significant at a 5% and 10% level, respectively.[3] In contrast, we observe that the terms related to economic conditions are statistically insignificant at all levels. This indicates that controlling for economic downturns in the US does not explain any variation in bond yields across time, though we note this might be captured by the included bond factors. The same holds for the interaction between the bad times dummy variable and state beta, meaning that the state beta does not have a differential marginal effect on yield during economic downturns in the US. Overall, we find that Model 3.1 captures 30.1% of the variation in the tax-adjusted municipal bond yields.

Furthermore, in Model 3.2 we include all the terms tested in Model 3.1 except the remaining maturity terms (see Appendix 1, Table 2, column 2). In this model, we find that the state beta is statistically significant at a 5% level, with a one unit increase in the state beta leading to an increase of 50 bps in the yield. As previously, we observe that the terms related to economic conditions remain insignificant. Overall, we note that Model 3.2 explains significantly less of the variation in bond yields, with a relatively low R^2 of 7.1%. The difference between Models 3.1 and 3.2, suggests that the effect of state betas is primarily concentrated in longer maturity bonds, which we test more formally in Model 3.3 where we include all the terms tested in Model 3.1 except the economic condition terms (see Appendix 1, Table 2, column 3). The significance levels of the intercept and maturity terms remains unchanged from Model 3.1. However, we find that the state beta flips signs and loses its statistical significance when analyzed in isolation compared to Model 3.2. However, the significance and magnitudes of the interaction terms for longer maturities are similar to Model 3.1. These findings indicate that most of the variation in the yield due to the state beta comes from bonds with medium to long

[3] We find that the coefficient of the state betas for the longer maturity bonds (25+ years) is of similar magnitude (50 bps), but not statistically significant. However, we caution that this result is potentially due to a limited set of bonds with longer maturities (Table 3 in Appendix 2 demonstrates that 90% of the bonds in our data has a total maturity and remaining maturity which is approximately 19 and 9 years, respectively), and thus could be indicative of limited power within this cohort. Moreover, bonds with a substantial maturity horizon beyond 25 years are primarily issued by high-quality issuers, which implies that bonds are highly rated and thus might have limited exposure to systematic risks.

remaining maturities such as 5-25 years. This means that a one unit increase in the state beta has an additional marginal effect of 50 bps on the yield when the remaining maturity of municipal bonds are within 5-25 years. A possible explanation for this result is that it is these bonds that have potential default/liquidity risk and thus are more exposed to systematic risks overall relative to shorter maturity bonds. Moreover, the lack of significance for longer maturity bonds, which are primarily issued by higher rated issuers, is consistent with this interpretation given the findings of Hull et al. (2005, p. 8), and Cornell and Green (1991, p. 47). Specifically, they argue that there is a greater impact on prices and returns of lower quality bonds compared to high quality bonds due to their greater exposure to systematic risk.

We conclude that Model 3.3 produces the most meaningful results. The R^2 of 29.6% demonstrates that this model captures significant variation in the tax-adjusted municipal bond yields while presenting insightful results compared to the other variations of Model 3. Generally, we observe that the effects on municipal bond yields do not vary across economic conditions. Instead, we find that most of the yield variation can be attributed to the different risk factors, remaining maturities, and their interactions with the state beta. Particularly, the state beta exhibits significant effects through the medium to long maturity bonds as we expect that these are more exposed to systematic risks compared to shorter maturities. We do not observe the same effect in shorter maturity bonds as it is highly unlikely for them to default given the rare occurrence of municipality defaults. Furthermore, Figure 1 in Appendix 1 demonstrates that state betas are persistent over time and can be considered stable compared to other risk factors. This indicates that they change too slowly as baseline regressors compared to yields which respond quickly to macroeconomic policies and other risks. However, the results suggest that the systematic correlation between states and the national US economy explains variation in yields for medium to long maturities beyond those accounted for by other fixed effects and risk factors.

6.4 Systematic Correlation Effect on Yield with State-Fixed Effects

We now test the extent that state betas explain the within-state time series variation in yields. Table 3 in Appendix 1 shows the regression results for Model 4.

Specifically, we regress the tax-adjusted municipal bond yield on the state beta, bond risk factors, and state-fixed effects. In column (1), we provide the results for the model which includes all the bond risk factors. The intercept is statistically significant at a 1% level, indicating that the average municipal bond yield in Alaska is 1.8%. From our results, we find that the state beta exhibits a slightly positive relationship with the yield, however, it is statistically insignificant at all levels. This indicates that the correlation between the state and national economy in the US has no effect on yield in isolation when we eliminate cross-sectional (across-state) variation.

Further, we look at state dummy variables to examine the contribution that individual states have on variation in yield. We observe that all the state dummy variables are statistically insignificant, except Illinois and Wyoming which are statistically significant at the 5% and 1% level, respectively. This indicates the yield in Illinois and Wyoming is greater relative to yield in Alaska by 150 and 100 bps. However, we remain doubtful about these findings as Illinois and Wyoming only represent approximately 4.3% of the transactions in our sample (see Appendix 2, Table 2). Hence, this indicates that state-fixed effects may not be necessary to consider in our study as individual states do not appear to have a substantial influence on the behavior of yields in isolation after accounting for other factors. Moreover, focusing on the bond risk factors, we observe that the majority demonstrate statistical significance at the 1% significance level, apart from the bond downside risk factor and corporate bond market excess return factors, which are significant at 5% level. The bond carry factor, bond short-term reversal factor, and the bond term structure factor are statistically insignificant. Thus, the state-fixed effects do not subsume the majority of risk factors.

Overall, the constructed model explains 20.1% of the variations in the tax-adjusted municipal bond yield. However, we observe that the explanatory power is partly attributed to the bond risk factors and the introduction of more variables through the state fixed effects, rather than the state beta. This indicates that variation in the systematic correlation between states and the national US economy does not affect the variation in yield when considering all risk factors and state-fixed effects.

In column (2), we refine Model 4 further by investigating the effect of the state beta on yield when only considering a selected set of risk factors. The regression results demonstrate that the state beta and state-fixed effects remain unchanged compared to the previous variation of Model 4. This indicates that the state beta is statistically insignificant at all levels when considering fewer bond risk factors. From the selected bond risk factors, we observe that the bond duration factor is the only risk factor that displays a statistically insignificant effect on the yield. Notably, the short-term reversal factor goes from having an insignificant negative effect to having a significant and slightly positive effect at the 1% level. Overall, we observe that the explanatory power of the model decreases to 15%, demonstrating a 5.1% decrease when only considering a limited set of risk factors. This is because the model includes fewer independent variables that exhibits a statistically significant effect on the yield. Although the excluded risk factors are statistically significant, we believe that they do not relate closely to municipal bonds and potentially cause multicollinearity in our model as some of the factors are closely linked. However, we forgo some explanatory power as our primary focus is the effect of the state beta on yield.

In column (3), we analyze Model 4 with the state beta and state fixed effects while excluding all the bond risk factors. As previously, we find that the coefficients and significance levels for both the state beta and state dummy variables remain unchanged. Therefore, the results of Model 4 with no risk factors follow the same pattern as the other variations meaning that the state beta is still statistically insignificant in isolation.

Overall, we observe that the F-statistic for Model 4 is only highly significant for the regressions with all and selected risk factors, excluding the possibility for junk regressions. As a result, we find that the model inclusive of all bond risk factors exhibits the greatest explanatory power compared to the other variations of Model 4, although majority is explained by the bond risk factors rather than the state beta. Consequently, we conclude that the state beta is statistically insignificant in explaining variation in the yield when considering state-fixed effects as seen across all variations of Model 4. This is supported by our observations in Figure 1 in Appendix 1. From this figure, we infer that there are additional factors with varying patterns in times of crisis, apart from the state beta, which can explain the behavior of economies and yields. Additionally, Figure 1 demonstrates that majority of the state betas stay at an all-states long-term average and remain relatively stable compared to the outlier states. Therefore, we find that other factors that are directly linked to bond risks have a greater impact on yield in our results.

6.5 Systematic Correlation Effect on Yield with Remaining Maturities Fixed Effects

As previously discussed, we find that the effect of state betas vary significantly across the maturities of the bonds. Therefore, some of the results in Table 3 could be due to the reduced effect of state betas on bonds with shorter maturities. We test for this in Table 4 in Appendix 1, which shows the regression results for Model 5. Specifically, we regress the tax-adjusted municipal bond yield on the state beta, bond risk factors, remaining maturities fixed effects, and state-fixed effects. In column (1), we find that the state beta for the shorter maturity bonds has a slightly negative relationship with the yield when considering all the bond risk factors. However, it is statistically insignificant at all levels which indicates that the state beta for shorter maturities bonds has no effect on the yield. In contrast, we find that the state beta exhibits a significant effect on yield for the bonds with remaining maturities between 5-15 years at a 5% level, where a one unit increase in state beta being associated with a 40 bps higher yield relative to maturities between 0-5 years. Furthermore, we observe a positive, though statistically insignificant effect for longer maturity bonds, though we note these are of similar magnitudes relative to Table 2. This indicates that the state level fixed effects have little effect on the magnitudes of the coefficients, and thus the lack of significance is likely due to more limited statistical power as a result of the reduced variation in within-state state betas.

In column (2), we observe minimal deviations when shifting Model 5 from all to selected risk factors. There is little to no variation in the state beta and all the remaining maturity terms, indicating that their significance levels persist without change. However, we observe deviations in the bond risk factors. Particularly, the bond duration risk factor maintains a lower statistical significance level of 10% rather than 1%. Meanwhile, the bond short-term reversal risk factor becomes significant at 1% significance level. Therefore, when introducing remaining maturity fixed effects alongside state-fixed effects, we find that duration risk captures less variation in yield while the opposite is true for the bond short-term reversal factor.

In column (3), we observe that the significance of the remaining maturity terms remains unchanged when excluding all the bond risk factors from the regression. Additionally, the intercept is significant and the greatest out of the three variations of Model 5. This shows that the average annualized yield for bonds in Alaska with remaining maturity between 0-5 years is 1.6%.

In conclusion, we observe that the introduction of remaining maturity fixed effects captures significant heterogeneity in the municipal bond yields. This is evident by the comparison of the explanatory powers for Model 4 and Model 5 inclusive of all risk factors. In Model 5, the R^2 increases from 20.1% to 39.9% after including the maturity affects (nearly doubling), which signifies the importance of duration risk implied by the remaining maturities. Particularly, the dummy variable and interaction term for remaining maturities between 5-15 years display a statistically significant effect on the yield. Therefore, controlling for various remaining maturities in the form of dummy variables and interaction terms is needed to capture variation in the yields sufficiently.

6.6 Systematic Correlation Effect on Yield with Economic Conditions Fixed Effects

Table 5 in Appendix 1 shows the regression results for Model 6. Specifically, we regress the tax-adjusted municipal bond yield on the state beta, bond risk factors, economic conditions fixed effects, remaining maturities fixed effects, and state-fixed effects. In column (1), we find that the state beta has a slightly negative relationship with yield when considering all the bond risk factors. However, in line with our previous findings, we find that the state beta remains statistically insignificant for bonds with shorter maturities. The economic conditions terms in this model exhibit a negative relationship with yield. The bad times dummy variable is statistically significant at a 5% level, demonstrating that the average level of yield falls by 50 bps during economic downturns (such as the period of 2008-2009 and 2020) compared to the non-crises times. Moreover, we also observe that the bad economic conditions interaction term is statistically insignificant at all levels. This indicates that the state beta has no marginal effect on yield during bad economic times. As default premiums are reflected in yield, it would be intuitive to observe that yield increases during economic downturns. However, according to Table 1 in Hull et al. (2005, p. 3), the real-world default intensity is minimal for high quality bonds compared to low quality bonds. Therefore, we do not see any marginal effect in the yield which is attributed to the state beta during bad economic times in our study. We still observe significant interaction coefficients for state betas and medium maturity bonds, and similar magnitude coefficients for state betas and longer term maturity bonds, indicating that the economic condition dummy variables do not absorb this effect.

In column (2), we find that the negative relationship between the bad economic times and yield persists. However, both terms representing bad economic conditions are statistically insignificant. This also holds true when running the regression without any risk factors as seen in column (3). Similar to prior specifications, we find that the state beta influences the yield through the interaction with the remaining maturity of 5-15 years as previously seen in Model 3 and Model 5. This indicates that the state beta has a significant marginal effect on yield by 40 bps for bonds with remaining maturity between 5-15 years, relative to bonds with remaining maturity between 0-5 years. The magnitude of this interaction remains constant in Model 5 or Model 6 across all risk factor assessments. Moreover, we find that the terms related to the bond risk factors, state-fixed effects, and remaining maturities follow the same pattern in Model 6 as in Model 5. Although the coefficients slightly change, we observe that the significance levels remain the same when we shift from testing the model with all bond risk factors to the selected risk factors.

In line with prior findings, we find that the R^2 steadily declines by approximately 4.5% as we shift Model 6 across the risk factor assessments. Specifically, the explanatory power of the model decreases from 40.9% to 36.1%, and lastly to 31.6%. Therefore, we believe that Model 6 does a slightly better job at capturing variation in the tax-adjusted municipal bond yields compared to Model 5 due to the introduction of the terms related to bad economic conditions. We find that the bad times interaction term is statistically insignificant in all the variations of Model 6. Therefore, we cannot confidently conclude that the state beta has any marginal effect on yield during economic downturns in the US. Moreover, we observe that there is a negative relationship between bad economic conditions and yield.

Particularly, in Model 6 inclusive of all risk factors, we find that the average level of yield was lower by 50 bps that during the period of 2008-2009 and 2020 compared to the non-crises times. Therefore, we argue that investors prefer to hold safer securities during times of crises. We assume that this will increase demand, resulting in higher prices and therefore lower yields. Further, we argue that the negative relationship between bad economic conditions and yield can be linked with unconventional monetary policy by the Fed. According to the graph from the Board of Governors of the Federal Reserve System (US) (2024), we observe that the Fed implemented quantitative easing to stimulate the US economy during poor economic conditions in 2008-2009 and 2020. Additionally, their plan to repurchase treasury bonds, MBS, and corporate debt resulted in a substantial announcement effect in the equity and debt markets (Rangvid, 2020). Consequently, we argue that the negative relationship between bad economic conditions and yield demonstrates that the yield does not only decrease for the treasury bonds, MBS, and corporate debt, but also for the municipal bonds. This could possibly be the result of a spillover effect of the Fed's signal for the economy as described by Rangvid. However, we cannot confidently state that the same effect on yield will persist in future crises as the Fed may implement alternative monetary policy strategies.

Overall, our findings point to relatively robust evidence of state betas being associated with higher yields for longer maturity bonds, with consistent positive and significant effects for bonds with remaining maturities of 5-15 years. Moreover, although insignificant in some specifications, we find that the coefficient on state betas for longer maturity bonds is relatively stable across specifications including state and economic condition fixed effects. This indicates that the effect is likely positive but may be difficult to detect due to limited statistical power from the low within-state variation in state betas.

6.7 Within-State Variation in State Beta

In Table 6 in Appendix 1, we formally examine the extent that state betas vary within the time series of a state. Specifically, in Model 7 we regress state betas on state-fixed effects. From our results, we observe that 39, 33, and 30 states are statistically significant at a 10%, 5%, and 1% level, respectively. From the R^2 and adjusted R^2, we observe that controlling for heterogeneity across different states in our regression captures 44.4% of the variation in the state beta. This is intuitive from an economic point of view due to the construction method of the state beta and its likelihood of persisting over time. Therefore, we infer that there is significant cross-sectional (across states) variation in the state beta that is captured by our model. However, there is still a significant portion of within-state time series variation that is not captured by controlling for state-fixed effects alone. Therefore, this test may help explain why we observe statistically significant effects of the state beta in the pooled regression and while more mixed results in the models with state fixed effects.

7 Conclusion

Our study finds that the systematic correlation between states and the national economy in the US has a significant effect on the tax-adjusted municipal bond yield primarily for bonds with medium to long maturities. Particularly, the effect that the state beta has on yield persist through the channel of bonds with medium to long remaining maturities such as 5-25 years.

Using the panel data on municipal bonds with monthly frequency in the US between 2005-2022 and various specifications allows us to examine the effect of the state beta on the tax-adjusted yields with and without the exclusion of constant effects that persist across different economic conditions and remaining maturities. Further, we investigate how the state beta behaves after the exclusion of effects that are constant across states in addition to the previously described effects. Across these specifications, we find relatively robust evidence that state betas are an important component in explaining the variation in bond yields for medium to long maturity bonds. Particularly, a one unit increase in state beta is associated with a 40-50 bps increase in the tax-adjusted yield of the bond, representing a roughly 20-25% increase relative to the mean. Moreover, we do not observe that there are significant changes in the marginal effects of the state betas during economic downturns as one might expect.

We argue that the main reason for the reduced power for longer maturities (25+ years) is due to the lack of observations in our data for these bonds and limited within-state time variation. This also applies to the marginal effect that the state beta would have within this cohort. In general, bonds with greater duration and therefore greater systematic risk will have higher yields. However, we argue that the increased systematic risk through the maturity is partially offset by the underlying characteristics of general obligation municipal bonds. As a result, the bonds with longer maturities are considered to be very close to risk-free and will only have a small and reduced significant effect on the yield. Similarly, Hull et al. (2005) finds that systematic risk has a greater impact on low-quality and risky bonds compared to safe and high-quality bonds. Despite these findings, we still observe that most of the variation in the tax-adjusted yield is attributed to the corporate bond factors from Dickerson et al. (2023) and maturity-fixed effects. Thus, we argue that it is important to consider the traditional bond factors, along with the effects of maturity, when explaining municipal bond yields. However, the inclusion of the systematic exposure of the issuer adds explanatory power and represents an important piece to explaining municipal bond yields for medium to long maturity bonds.

There is limited literature which discusses the effect that a systematic exposure proxy has on yield, as most related research focus on default risk and liquidity as determinants (Schwert, 2017). In previous literature, Tuzel and Zhang (2017) argues that local risk has a direct impact on firm risk as they observe an inverse relationship between local risk and the industry-adjusted returns. In contrast, our study contributes to the literature on municipal bonds as we find that the systematic risk of local areas exhibits a significant positive relationship with yield. However, a limitation of our research could be the imperfection of the obtained data which may cause the tax-adjusted yields and state betas to be estimated with increased noise. As a result, the values of the yields and state betas may deviate from the true values that economies imply. Therefore, we see that there is potential for future research in finding different proxies for the correlation between states and the national US economy along with richer data covering longer sample periods to estimate the effect of the systematic correlation more precisely. Moreover, it is worth exploring the impact that the systematic correlation has on lower quality bonds (i.e., corporate bonds) as these have greater exposure to systematic risk and may therefore allow the state beta to demonstrate greater explanatory power in their yield.

8 Appendix 1

Figure 1: State Beta Value by State and Year

This figure demonstrates the systematic exposure (state beta) for all the US states from 1992 to 2022, thus illustrating the results from Model 1. The state betas have been generated by running a 5-year rolling window regression with the state HPI returns as the dependent variable and national HPI returns as the independent variable. The red cells show strong positive systematic correlation, and the blue cells show strong negative systematic correlation. The lighter red and blue cells suggest moderate to negligible positive and negative systematic correlation as the state beta approaches zero.

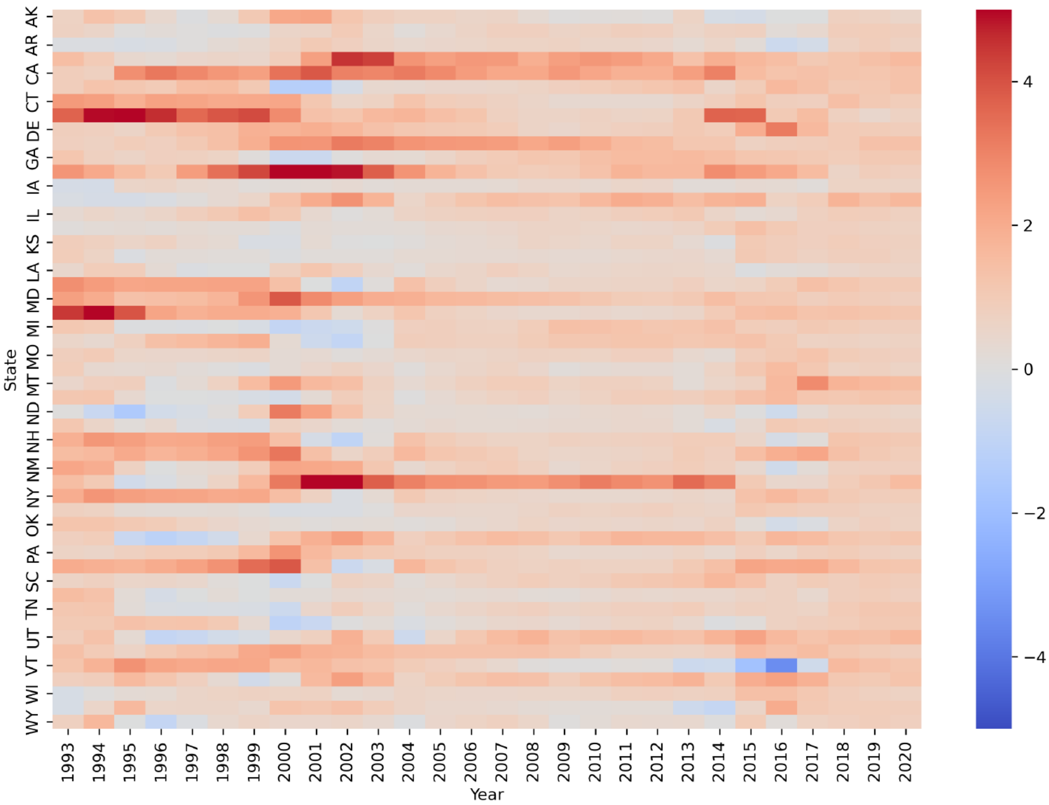

Figure 2: Correlation Matrix of Corporate Bond Risk Factors

This figure presents the correlations between all the 14 traded corporate bond factors from Dickerson et al. (2023). The red cells show strong positive correlation, and the blue cells show strong negative correlation. The lighter red and blue cells suggest moderate to negligible positive and negative correlation.

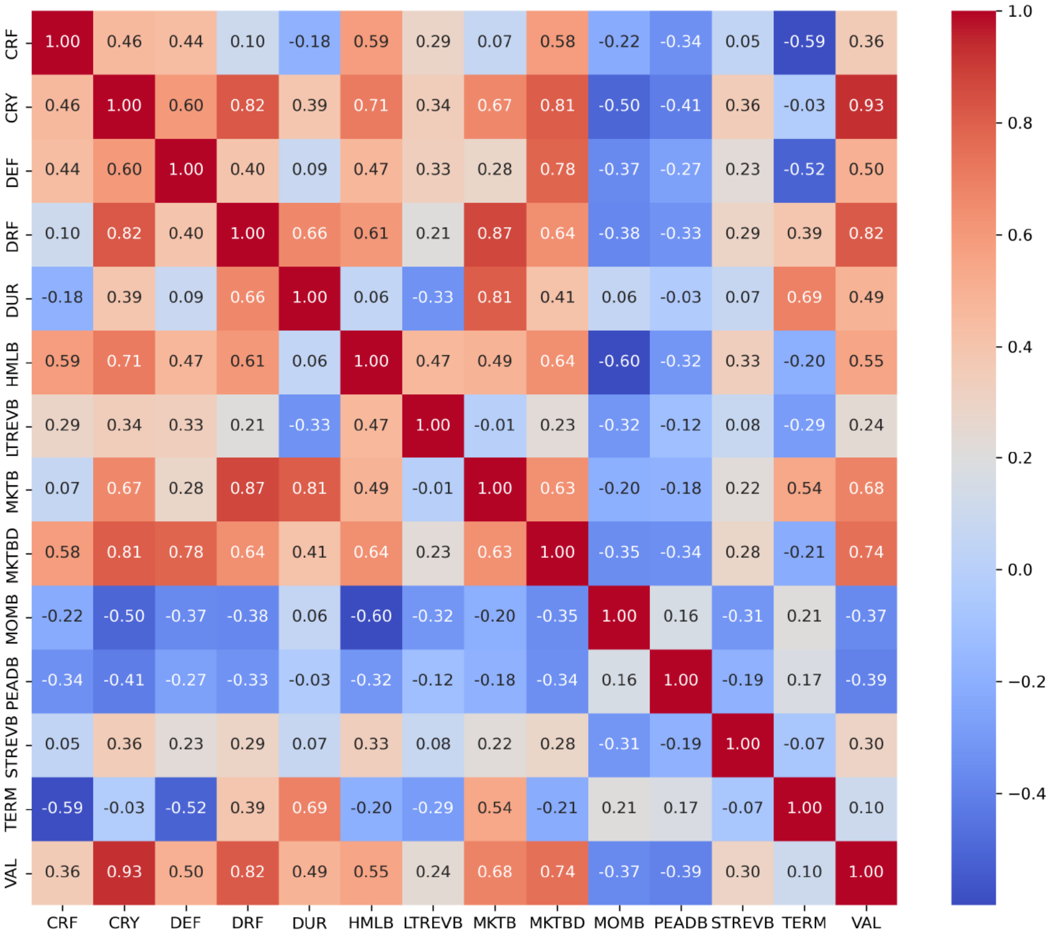

Table 1: Regression Results for Model 2 – State Beta Effect on Yield

This table summarizes the regression results obtained from Model 2, covering the period 2005-2022. Tax-adjusted yield is the dependent variable which is regressed on the corporate bond factors from Dickerson et al. (2023). In column (1), we include the state beta, while column (2) excludes the state beta. State FE is the indicator that signifies whether the model controls for state-fixed effects.

	Dependent variable: TA Yield	
	(1)	(2)
Intercept	0.017***	0.021***
	(0.000)	(0.000)
State Beta	0.004***	
	(0.000)	
CRF	-0.263***	-0.262***
	(0.002)	(0.002)
CRY	-0.108***	-0.110***
	(0.005)	(0.005)
DEF	0.113***	0.106***
	(0.003)	(0.003)
DRF	0.326***	0.333***
	(0.005)	(0.005)
DUR	-0.508***	-0.515***
	(0.004)	(0.004)
HMLB	0.191***	0.188***
	(0.003)	(0.003)
LTREVB	-0.350***	-0.348***
	(0.003)	(0.003)
MKTB	0.222***	0.238***
	(0.005)	(0.005)
MKTBD	0.355***	0.354***
	(0.005)	(0.005)
MOMB	0.108***	0.110***
	(0.001)	(0.001)
PEADB	0.673***	0.689***
	(0.006)	(0.007)
STREVB	-0.013***	-0.012***
	(0.001)	(0.001)
TERM	0.079***	0.076***
	(0.003)	(0.003)
VAL	-0.187***	-0.189***
	(0.005)	(0.005)
State FE	No	No
State Beta	Yes	No
Observations	811078	811078
R^2	0.106	0.087
Adjusted R^2	0.106	0.087
Residual Std. Error	0.016 (df=811062)	0.017 (df=811063)
F Statistic	6426.131*** (df=15; 811062)	5509.990*** (df=14; 811063)
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 2: Regression Results for Model 3 – State Beta Effect on Yield without State-Fixed Effects

This table summarizes the regression results obtained from Model 3, covering the period 2005-2022 with a limited set of corporate bond factors from Dickerson et al. (2023). Namely, bond default, duration, value, and the short-term reversal risk factors. In column (1), the yield is regressed on the state beta, bond factors, and terms related to bad economic conditions and remaining maturities. In column (2), the yield is regressed on the state beta, bond factors, and terms related to bad economic conditions. In column (3), the yield is regressed on the state beta, bond factors, and terms related to remaining maturities. The bad economic conditions are defined as the years 2008, 2009 and 2020.[4] State FE is the indicator that signifies whether the model controls for state-fixed effects.

	Dependent variable: TA Yield		
	(1)	(2)	(3)
Intercept	0.015***	0.018***	0.015***
	(0.001)	(0.002)	(0.001)
State Beta	0.000	0.005**	-0.001
	(0.001)	(0.002)	(0.001)
DEF	0.061***	0.031	0.074***
	(0.019)	(0.021)	(0.019)
DUR	-0.034*	-0.025	-0.033*
	(0.018)	(0.024)	(0.018)
STREVB	0.097***	0.082***	0.087***
	(0.016)	(0.019)	(0.015)
VAL	-0.144***	-0.119***	-0.152***
	(0.026)	(0.039)	(0.028)
Bad Times	-0.001	-0.002	
	(0.002)	(0.003)	
Bad Times × State Beta	-0.002	-0.004	
	(0.002)	(0.003)	
Rem. Mat. 5-15y.	0.009***		0.008***
	(0.002)		(0.002)
Rem. Mat. 15-25y.	0.035***		0.035***
	(0.004)		(0.004)
Rem. Mat. 25y. and onwards	0.027		0.026
	(0.022)		(0.022)
Rem. Mat. 5-15y. × State Beta	0.005**		0.005**
	(0.002)		(0.002)
Rem. Mat. 15-25y. × State Beta	0.005*		0.005*
	(0.003)		(0.003)
Rem. Mat. 25y. and onwards × State Beta	0.005		0.006
	(0.011)		(0.011)
State FE	No	No	No
Observations	811078	811078	811078
R^2	0.301	0.071	0.296
Adjusted R^2	0.301	0.071	0.296
Residual Std. Error	0.015 (df=811064)	0.017 (df=811070)	0.015 (df=811066)
F Statistic	111.619*** (df=13; 811064)	19.712*** (df=7; 811070)	127.433*** (df=11; 811066)

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors are clustered.

[4] We infer that these years demonstrate economic downturns from the graph of Annual growth of the real gross domestic product of the United States from 1990 to 2023 from U.S. Bureau of Economic Analysis (2024).

Table 3: Regression Results for Model 4 – State Beta on Yield with State-Fixed Effects

This table summarizes the regression results obtained from Model 4, covering the period 2005-2022. Tax-adjusted yield is the dependent variable that is regressed on the state beta, state-fixed effects, along with all, selected, and none of the corporate bond factors from Dickerson et al. (2023) in the columns (1), (2), and (3), respectively. State FE is the indicator that signifies whether the model controls for state-fixed effects. The results for the state-fixed effects are not reported as majority are statistically insignificant at any significance level, apart from Illinois and Wyoming.

	Dependent variable: TA Yield		
	(1)	(2)	(3)
Intercept	0.018***	0.019***	0.019***
	(0.003)	(0.003)	(0.003)
State Beta	0.001	0.001	0.001
	(0.002)	(0.002)	(0.003)
DEF	0.120***	0.057***	
	(0.038)	(0.018)	
CRF	-0.267***		
	(0.040)		
DUR	-0.488***	-0.025	
	(0.095)	(0.023)	
DRF	0.298**		
	(0.119)		
CRY	-0.072		
	(0.076)		
STREVB	-0.008	0.068***	
	(0.024)	(0.015)	
HMLB	0.183***		
	(0.045)		
TERM	0.072		
	(0.064)		
MKTB	0.191**		
	(0.088)		
MKTBD	0.326***		
	(0.105)		
PEADB	0.634***		
	(0.105)		
MOMB	0.101***		
	(0.025)		
VAL	-0.187***	-0.137***	
	(0.049)	(0.034)	
LTREVB	-0.355***		
	(0.074)		
State FE	Yes	Yes	Yes
Observations	811078	811078	811078
R^2	0.201	0.150	0.114
Adjusted R^2	0.201	0.150	0.114
Residual Std. Error	0.016 (df=811014)	0.016 (df=811024)	0.016 (df=811028)
F Statistic	28.787*** (df=63; 811014)	4.559*** (df=53; 811024)	1.109 (df=49; 811028)
Note:			*p<0.1; **p<0.05; ***p<0.01 Standard errors are clustered.

Table 4: Regression Results for Model 5 – State Beta on Yield with Remaining Maturities Fixed Effects

This table summarizes the regression results obtained from Model 5, covering the period 2005-2022. Tax-adjusted yield is the dependent variable that is regressed on the state beta, terms related to remaining maturities, along with all, selected, and none of the corporate bond factors from Dickerson et al. (2023) in the columns (1), (2), and (3), respectively. State FE is the indicator that signifies whether the model controls for state-fixed effects. The results for the state-fixed effects are not reported as majority are statistically insignificant at any significance level, apart from Illinois and Wyoming.

	Dependent variable: TA Yield		
	(1)	(2)	(3)
Intercept	0.014***	0.015***	0.016***
	(0.002)	(0.002)	(0.002)
State Beta	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.002)
CRF	-0.261***		
	(0.036)		
CRY	0.097		
	(0.061)		
DEF	0.156***	0.076***	
	(0.030)	(0.018)	
DRF	0.141		
	(0.096)		
DUR	-0.364***	-0.034*	
	(0.073)	(0.018)	
HMLB	0.162***		
	(0.037)		
LTREVB	-0.367***		
	(0.055)		
MKTB	0.052		
	(0.072)		
MKTBD	0.183**		
	(0.085)		
MOMB	0.076***		
	(0.020)		
PEADB	0.463***		
	(0.081)		
STREVB	0.010	0.089***	
	(0.021)	(0.014)	
TERM	0.050		
	(0.054)		
VAL	-0.194***	-0.154***	
	(0.040)	(0.025)	
Rem. Mat. 25y. and onwards	0.020	0.022	0.020
	(0.020)	(0.020)	(0.020)
Rem. Mat. 25y. and onwards × State Beta	0.005	0.005	0.005
	(0.010)	(0.010)	(0.010)
Rem. Mat. 15-25y.	0.033***	0.034***	0.032***
	(0.003)	(0.003)	(0.003)
Rem. Mat. 15-25y.× State Beta	0.004	0.004	0.004
	(0.002)	(0.003)	(0.003)
Rem. Mat. 5-15y.	0.009***	0.009***	0.008***
	(0.002)	(0.002)	(0.002)
Rem. Mat. 5-15y.× State Beta	0.004**	0.004**	0.004**
	(0.002)	(0.002)	(0.002)
State FE	Yes	Yes	Yes
Observations	811078	811078	811078
R^2	0.399	0.356	0.309
Adjusted R^2	0.399	0.356	0.309
Residual Std. Error	0.014 (df=811008)	0.014 (df=811018)	0.014 (df=811022)
F Statistic	79.603*** (df=69; 811008)	44.979*** (df=59; 811018)	19.543*** (df=55; 811022)

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors are clustered.

Table 5: Regression Results for Model 6 – State Beta on Yield with Economic Conditions Fixed Effects

This table summarizes the regression results obtained from Model 6, covering the period 2005-2022. Tax-adjusted yield is the dependent variable that is regressed on the state beta, state-fixed effects, and terms related to bad economic conditions and remaining maturities. This model is tested with all, selected and none of the corporate bond factors from Dickerson et al. (2023) in the columns (1), (2), and (3), respectively. As in Model 3, the bad economic conditions are defined as the years 2008, 2009 and 2020. State FE is the indicator that signifies whether the model controls for state-fixed effects. The results for the state-fixed effects are not reported as majority are statistically insignificant at any significance level, apart from Illinois and Wyoming.

	Dependent variable: TA Yield		
	(1)	(2)	(3)
Intercept	0.014***	0.015***	0.016***
	(0.002)	(0.002)	(0.003)
State Beta	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)
CRF	-0.257***		
	(0.033)		
CRY	0.281***		
	(0.072)		
DEF	0.127***	0.063***	
	(0.035)	(0.017)	
DRF	0.010		
	(0.099)		
DUR	-0.306***	-0.035**	
	(0.080)	(0.018)	
HMLB	0.154***		
	(0.037)		
LTREVB	-0.348***		
	(0.056)		
MKTB	0.112		
	(0.072)		
MKTBD	0.090		
	(0.085)		
MOMB	0.087***		
	(0.022)		
PEADB	0.573***		
	(0.083)		
STREVB	0.023	0.099***	
	(0.021)	(0.016)	
TERM	0.021		
	(0.058)		
VAL	-0.264***	-0.146***	
	(0.050)	(0.023)	
Rem. Mat. 25y. and onwards	0.022	0.023	0.022
	(0.020)	(0.020)	(0.021)
Rem. Mat. 25y. and onwards × State Beta	0.004	0.004	0.004
	(0.010)	(0.010)	(0.010)
Rem. Mat. 15-25y.	0.033***	0.034***	0.033***
	(0.003)	(0.003)	(0.003)
Rem. Mat. 15-25y. × State Beta	0.004	0.004	0.004
	(0.002)	(0.002)	(0.003)
Rem. Mat. 5-15y.	0.009***	0.009***	0.008***
	(0.001)	(0.002)	(0.002)
Rem. Mat. 5-15y. × State Beta	0.004**	0.004**	0.004**
	(0.002)	(0.002)	(0.002)
Bad Times	-0.005**	-0.003	-0.003
	(0.002)	(0.002)	(0.002)
Bad Times × State Beta	-0.001	-0.001	-0.000
	(0.002)	(0.002)	(0.002)
State FE	Yes	Yes	Yes
Observations	811078	811078	811078
R^2	0.409	0.361	0.316
Adjusted R^2	0.409	0.360	0.316
Residual Std. Error	0.013 (df=811006)	0.014 (df=811016)	0.014 (df=811020)
F Statistic	172.534*** (df=71; 811006)	43.965*** (df=61; 811016)	22.446*** (df=57; 811020)

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors are clustered.

Table 6: Regression Results for Model 7 – State Fixed Effects on State Beta

This table summarizes the regression results obtained from Model 7. The state beta is the independent variable which is regressed on state-fixed effects. The state-fixed effects are dummy variables that take the value of 1 for the corresponding state and 0 otherwise.

	Dependent variable: State Beta
	(1)
Intercept	0.282*
	(0.169)
AL_Dummy	0.379*
	(0.206)
AR_Dummy	-0.049
	(0.298)
AZ_Dummy	1.247***
	(0.220)
CA_Dummy	1.476***
	(0.282)
CO_Dummy	0.811***
	(0.206)
CT_Dummy	0.647***
	(0.224)
DE_Dummy	1.267***
	(0.384)
FL_Dummy	0.852***
	(0.189)
GA_Dummy	0.948***
	(0.196)
HI_Dummy	1.475***
	(0.411)
IA_Dummy	0.173
	(0.196)
ID_Dummy	1.129***
	(0.269)
IL_Dummy	0.417**
	(0.183)
IN_Dummy	0.536***
	(0.193)
KS_Dummy	0.356*
	(0.211)
KY_Dummy	0.399**
	(0.190)
LA_Dummy	0.157
	(0.176)
MA_Dummy	0.637***
	(0.200)
MD_Dummy	0.778***
	(0.186)

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Table 6: Continued from the previous page

	Dependent variable: State Beta
	(1)
ME_Dummy	0.914***
	(0.187)
MI_Dummy	0.734***
	(0.185)
MN_Dummy	0.673***
	(0.191)
MO_Dummy	0.599***
	(0.226)
MS_Dummy	0.567***
	(0.219)
MT_Dummy	1.142***
	(0.253)
NC_Dummy	0.921***
	(0.184)
ND_Dummy	0.076
	(0.252)
NE_Dummy	0.273
	(0.211)
NH_Dummy	0.442
	(0.281)
NJ_Dummy	1.056***
	(0.255)
NM_Dummy	0.078
	(0.309)
NV_Dummy	1.145***
	(0.417)
NY_Dummy	0.740***
	(0.232)
OH_Dummy	0.531***
	(0.180)
OK_Dummy	0.034
	(0.274)
OR_Dummy	1.165***
	(0.196)
PA_Dummy	0.363*
	(0.189)
RI_Dummy	1.282***
	(0.223)
SC_Dummy	0.809***
	(0.229)
SD_Dummy	0.432**

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Table 6: Continued from the previous page

	Dependent variable: State Beta
	(1)
	(0.199)
TN_Dummy	0.555***
	(0.194)
TX_Dummy	0.364*
	(0.214)
UT_Dummy	1.168***
	(0.204)
VA_Dummy	0.770***
	(0.194)
VT_Dummy	-0.882
	(0.928)
WA_Dummy	1.191***
	(0.263)
WV_Dummy	0.653*
	(0.364)
WY_Dummy	0.036
	(0.178)
Observations	811078
R^2	0.444
Adjusted R^2	0.444
Residual Std. Error	0.484 (df=811029)
F Statistic	10.441*** (df=48; 811029)
Note:	*p<0.1; **p<0.05; ***p<0.01
	Standard errors are clustered.

9 Appendix 2

Table 1: Data Cleaning Results

This table demonstrates the amount of unique bonds and transactions before and after data cleaning. The cleaning procedure has been described in section 3. The final sample is utilized in our models.

Data	Bonds	Transactions
Raw sample	9,170,494	144,914,868
Final sample	36,752	811,078

Table 2: Transaction Percentages by State

This table demonstrates the percentage of transactions per state in our final sample.

State	**Transaction (%)**	**State**	**Transaction (%)**
Alabama	0.66	Montana	0.22
Alaska	0.49	Nebraska	0.39
Arizona	2.41	Nevada	0.62
Arkansas	0.07	New Hampshire	0.42
California	18.66	New Jersey	4.70
Colorado	1.53	New Mexico	0.43
Connecticut	2.29	New York	6.97
Delaware	0.45	North Carolina	1.92
Florida	0.68	North Dakota	0.06
Georgia	1.10	Ohio	2.98
Hawaii	1.24	Oklahoma	0.45
Idaho	0.17	Oregon	2.68
Illinois	4.27	Pennsylvania	4.27
Indiana	0.08	Rhode Island	0.23
Iowa	0.54	South Carolina	1.04
Kansas	0.79	South Dakota	0.07
Kentucky	0.17	Tennessee	1.52
Louisiana	0.71	Texas	15.72
Maine	0.39	Utah	0.88
Maryland	2.37	Vermont	0.20
Massachusetts	3.34	Virginia	2.15
Michigan	3.22	Washington	3.33
Minnesota	1.94	West Virginia	0.21
Mississippi	0.26	Wyoming	0.01
Missouri	0.73		

Table 3: Bond Characteristics

This table demonstrates the municipal bond characteristics of the final sample.

	Mean	StDev	Min	Max	p1	p10	p25	p50	p75	p90
Tax adjusted yield (%)	2	2	0	44	0	1	1	2	3	4
Coupon Rate (%)	4.05	1.67	0	10.19	0	0	4	5	5	5
Total par traded ($)	681,140.71	3,904,446.61	237	527,330,000	10,000	20,000	40,000	100,000	300,000	955,000
MWA dollar price ($)	108.59	15.12	50	149.28	53.29	89.94	105.73	111.42	117.37	122.28
Years since Issuance	4.37	4.01	0	30.92	0.21	0.8	1.65	3.26	5.54	9.44
Remaining Maturity	5.71	3.15	1.04	37.08	1.29	2.29	3.45	5.20	7.25	9.33
Total Maturity	10.08	5.29	2.03	40	3.86	5.87	7.14	8.79	9.99	19.15

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