The Term Structure of State Bond Interest Rates

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ABSTRACT

This paper uses daily trade data from the EMMA database (Electronic Municipal Market Access) for the period 2004-2012 to examine the behavior of interest rates on state-issued bonds, particularly the influence of local employment shocks on state bond yields and premiums relative to US Treasury rates. This is a topic of important public policy relevance due to the budget woes of many of the US states since prices of fixed-income securities are influenced by changing beliefs about the riskiness of the future cash flows.

INTRODUCTION

This study uses a panel of bond data from the *Emma* online database, Electronic Municipal Market Access, provided by the Municipal Securities Rulemaking Board (MSRB). We concentrate on general obligation bonds issued by US states. Whereas some bonds might be backed by specific revenue streams (toll roads, hospitals, universities or the like), general obligation bonds are ultimately guaranteed by tax revenue, "the full faith and credit of the State." The contribution of this study is to document the ways in which the spread of state general obligation bonds from Treasuries varies with information about state economic conditions.

The muni market underwent major innovations as the 2009 US federal stimulus allocated money to states for them to issue non-tax-advantaged bonds. Although most US capital markets have become internationalized in past decades, peculiarities in tax treatment of munis has meant that these markets do not attract much foreign investment. Muni yields are low since they are tax-free so a foreign investor, which would not benefit from the tax avoidance, would be deterred by the lower yields. State borrowing is implicitly subsidized by federal taxation. The federal government instituted a new program ("Build America Bonds") that would convert these implicit subsidies into explicit payments from the federal to state level; states would benefit by selling their bonds to a deeper international market. Although this study does not address this new development (all analysis excludes the new non-tax-preferred bonds), these developments remind us how important the muni market is to questions of public finance.

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Literature Review

The most important finding from various studies of the muni market is to establish a puzzle that the different state yields are not adequately explained by marginal tax rates, so other risk characteristics of the bonds are more important to establish their prices and yields. This initial insight was formalized in Miller (1977) that bonds with different tax rates but otherwise identical risks would equalize their post-tax rate of return. Differences that are not explained by tax are therefore attributed to various risks. However data limitations of previous studies have often meant using annual or even lower-frequency data to establish rough correlations: the richness of the underlying market data was difficult to explore.

There are a few prior studies using the high-frequency trade data from EMMA rather than indexes or other second-hand data. Ang et al (2010) use EMMA data for the period 1995-2007 to compare taxed and un-taxed bond prices issued by the same entity, identifying differences due both to default and liquidity risk. They attempt to isolate the liquidity risk by partitioning bonds by quantile of number of trades. They conclude that the price reaction to taxes is too high for a rational story, but the preponderance of individual trades means that it is difficult for other participants to arbitrage this overreaction. Downing and Zhang (2004), also with EMMA data, use weekly intervals to account for the infrequency with which state bonds are often traded. Deng and McCann (2013) find some evidence that the new EMMA access to bond data has reduced markups for market makers. Wang et al (2005) construct an aggregate liquidity measure from EMMA data to assess an individual bond's 'beta' with respect to this liquidity measure, using data from 2000-2004. The liquidity differential also helps explain the finding that the tax-implied spread changes by maturities. Harris and Piwowar (2006) use MSRB data from 1999-2000 to estimate that trading costs are 1-2% of the transaction in the market for state bonds. Pirinsky and Wang (2011) provide evidence that the highly segmented markets result in higher bond returns.

Chalmers (1998) uses grid prices of various bonds including defeased bonds to show that actual prices are not well explained by tax differentials. Kadiyala (2007) uses index data from 1995-2005 to estimate a liquidity premium to explain part of the puzzle that tax rates and default rates alone are insufficient to explain the spread of municipal bonds from corporate bonds. This premium is measured following Longstaff (1995), who derives an upper bound on the discount for lowered liquidity. Other studies such as Kriz (2004) estimate the magnitude of default probabilities, although using index data for 1993-1999.

Nadler and Hong (2011) use data from a Bloomberg index of hypothetical generic bonds. They identify the spread from Treasury as the default risk, as a function of state GDP, deficit/state GDP ratio, and unemployment rate, as well as measures of political affiliation and union strength. They have annual data on budgets and concentrate their analysis on lower-frequency (annual) information. Daniels et al (2010) compare issuance of munis and corporate bonds.

Another source of information is muni bond funds; Chen et al (2011) document calendar effects at quarter ends and especially year ends, documenting the residual importance of tax avoidance. (Jones and Stroup, 2013) use annual state data, along with Fama-French factors, to explain mispricing of closed-end funds of state bonds.

(Poterba and Ramírez, 2011) provide a range of estimates for the size of the subsidy due to the exemption of state bonds from federal income tax, using data from the Fed's Survey of Consumer Finances. Poterba and Rueben (1999) examine how state political factors such as balanced-budget requirements and spending limits, as well as state unemployment rates, can impact bond yields using data from 1973-1999, using data from a survey of bond traders.

Data

The markets for bonds of the largest state issuers are large and liquid. Table 1 shows the top ten states by average daily par amount traded in 2009-2012. There was a precipitous drop of trading after the Financial Crisis: from 2008 to 2009 the value of trades dropped 31%; from 2009 to 2010 there was only a slight drop of one-third of a percent. Most of the drop was in Auction Rate and Variable Rate securities after those auctions failed in the Crisis; these are omitted from the current analysis. The focus of uncertainty turned to the financial conditions of the issuers.

Table 1: Average Daily Par Amount of All Muni Bonds by State

	2009	**2010**	**2011**	**2012**
California	3146	2833	2320	2080
New York	1702	1742	1613	1690
Texas	1245	1261	1120	1289
Florida	911	757	530	486
Illinois	530	635	556	497
New Jersey	448	490	459	537
Pennsylvania	531	512	451	437
Massachusetts	479	486	448	413
Ohio	344	358	310	280
Georgia	371	288	229	187

Source: MSRB Factbook, 2012.

The interest rate on munis differs from the rate offered on US Treasuries for two important reasons: the tax advantages of municipal bonds that are exempt from US income taxation and the risk characteristics of the future cash flows. The changes to federal tax law are infrequent and well anticipated. The risk characteristics change at a higher frequency and are the subject of the current study.

Defaults are quite rare however; a study by Moody's in 2010 found that munis defaulted at a rate of just 0.09% over a decade whereas corporates had a default rate of just over 11% over a decade; most muni defaults (over 90%) were not general obligation bonds.

There are 1,985,343 observations for general obligation bonds of 35 different states in various series in 2004-2012 that have positive yields and were bought or sold for external customers (not inter-dealer trades). From the reported bond price, the implied yield-to-maturity is calculated for each traded security; the bonds of each state, in each time period, are fit to a zero coupon yield curve by the Nelson-Siegel method.

The time to maturity of bonds traded is shown in table 2, listing the fraction of the sample at each interval. Muni bonds are thickly traded all along the yield curve.

Table 2: Time to Maturity of State Bonds

1 year or less	0.132
2-5 years	0.237
6-10 years	0.233
10-20 years	0.287
21+ years	0.110

Source: Authors' calculations based on EMMA data.

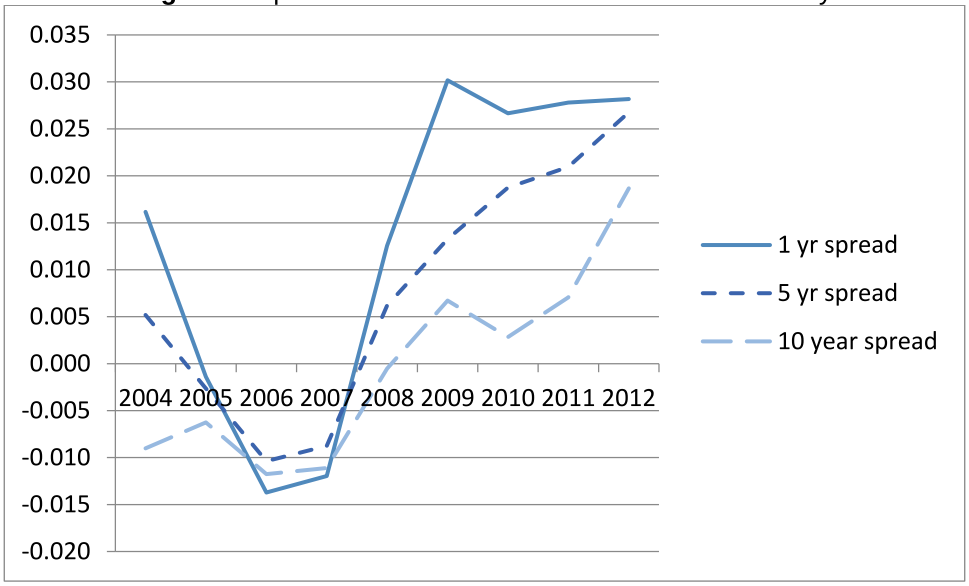
These bond trades for each state are used to construct constant-maturity yields. Perhaps the most surprising aspect of the yields is that it is nearly impossible to distinguish the years before and after the Financial Crisis, even though this means that the spreads from Treasuries inverted.

Figure 3 shows the spread, measured as state yield minus the Treasury rate so that the 'normal' value is negative. For California's ten-year bonds, before the Crisis, yields were about a percentage point less than Treasuries; after the crisis, yields were higher than Treasuries.

What models could account for this behavior? One model would assert that simply the state bond market is segmented from the Treasury market, that market participants believe that state and federal bonds are very poor substitutes. Alternately, the risks of the individual states changed from those of the federal government. If much of the change represents a huge injection of liquidity by the Federal Reserve into the Treasury market, then this can simply be considered as a relative change in liquidity risk between state and federal obligations. Nevertheless in any of these cases, we would expect to see differences among states since their economic experiences showed significant variation.

There is enormous heterogeneity in state bond yields. Using monthly 1-year maturities for 27 states with comprehensive data availability (at least 100 of the 108 months in the sample), a factor analysis shows little common movement in the state yields: the first principal component explains just 9.3% of the variance.

Figure 3: Spread of California State Yields minus Treasury



Source: Authors' calculations based on EMMA data.

Daily yields on state general revenue bonds are not well explained by contemporary movements in Treasuries. For example, table 3 shows the R-squared for regressions explaining daily yields of general obligation bonds of New York State, depending on the entire yield curve of Treasuries (from one month bills to 10-year bonds)

Table 3: R^2 for regressions of indicated dependent variable on Treasury yield curve rates

New York State:	1m yields	3m yields	6m yields	1yr yields	5yr yields	10yr yields
R^2	0.068	0.041	0.045	0.031	0.053	0.125

Source: Author calculations using data from EMMA and Fed Board of Governors

Clearly 85-90% of the variation in muni yields is not explained by Treasury movements. It would be useful to investigate other factors that influence the muni yields, particularly if these yields reflect market expectations of state solvency.

To determine how state-level economic shocks affect these yields, we use monthly state employment data from the US Bureau of Labor Statistics. These are collected based on the twelfth day of each month (except when that is a weekend or holiday, when BLS uses the working day prior). State employment data is likely to be a good proxy for state financial conditions and ability to pay, since state revenues depend on tax receipts. State employment data is also reported in a coherent standardized way by an agency external to the various states. As other sovereign entities such as Greece or Argentina have demonstrated, economic statistics collected by local agencies are susceptible to political manipulation. In the case of the US Bureau of Labor Statistics, their collection and reporting methodology is meant to be impartial.

Estimation

First we estimate monthly bond yields affected by state employment shocks. We experiment with specifying the dependent variable as either the state bond yield or the difference between the state bond yield and US Treasuries. Notate the interest rate on τ-year maturity bonds for state j in month t as $r_{j,t}^{\tau}$; the US Treasury rate as R_t^{τ}; so the dependent is either $r_{j,t}^{\tau}$ or $\left(r_{j,t}^{\tau} - R_t^{\tau}\right)$. To the extent that state bonds are segmented from the Treasury market we would expect that the first specification would be more appropriate; if the risk is different from Treasury rates then the second specification would be more informative. Both the bond yields and employment data refer to the same time, the twelfth day of the month or, if that day is a holiday, the work day before. Bond yields are observed on that day although the employment report is published subsequent.

We begin with a basic regression where the dependent variable is the one year maturity state bond yields, while the independent variables include the level or log of state employment, $Empl_{j,t}$ fixed effects for each of the 35 issuing states, α_j, and year/month dummies, γ_t, m_t, so

$$r_{j,t}^{\tau} = \alpha_j + \gamma_t + m_t + \beta Empl_{j,t} + \varepsilon_{j,t}^{\tau}.$$

We would expect that positive employment growth would lower the state interest rate while negative employment shocks would make the state's borrowing relatively riskier, increasing the yield – so we would expect β<0. The regression results for one-year maturity are in table 4.

Table 4: State Bond Yields, 1 year maturity

	Empl	**ln(Empl)**	**Empl**	**ln(Empl)**
coefficient	-1.255e-06	-0.00692	-4.282e-07	0.000277
t-stat	-1.480	-1.582	-0.444	0.044
state fixed effects	y	y	y	y
time dummies	n	n	y	y

For 35 states with general-obligation bonds, monthly 2004-2012, dependent is state yield.

These estimates are generally insignificantly different from zero. For the next specification we use the difference of state bond yields from Treasuries, with estimation results in table 5.

$$r_{j,t}^{\tau} - R_t^{\tau} = \alpha_j + \gamma_t + m_t + \beta Empl_{j,t} + \varepsilon_{j,t}^{\tau}.$$

Table 5: State Bond Yields Difference from Treasuries, 1 year maturity

	Empl	**ln(Empl)**	**Empl**	**ln(Empl)**
coefficient	-4.88e-05	-0.378695	-2.48e-06	-0.02774
t-stat	-21.575	-35.620	-2.235	-3.793
state fixed effects	y	y	y	y
time dummies	n	n	y	y

For 35 states with general-obligation bonds, monthly 2004-2012, dependent is state yield minus Treasury yield.

In these estimates, the specifications of the difference of state yields from Treasuries, the estimated coefficients are statistically significant and with the expected sign. Next we examine the 5-year maturity, table 6.

Table 6: State Bond Yields, 5 year maturity

Dependent is State Bond Yield, 5 year maturity				
	Empl	**ln(Empl)**	**Empl**	**ln(Empl)**
coefficient	8.555e-07	0.0060919	6.261e-07	6.63e-03
t-stat	1.445	1.994	0.929	1.495
state fixed effects	y	y	y	y
time dummies	n	n	y	y
Dependent is State Bond Yield minus Treasury, 5 year maturity				
	Empl	**ln(Empl)**	**Empl**	**ln(Empl)**
coefficient	-4.67e-05	-0.366283	-1.41e-06	-0.02109
t-stat	-21.698	-36.427	-1.660	-3.771
state fixed effects	y	y	y	y
time dummies	n	n	y	y

For 35 states with general-obligation bonds, monthly 2004-2012, dependent is state yield in top panel; state yield minus Treasury in bottom panel.

The coefficient estimates are quite stable, as we move from the one-year to the five-year maturities, implying that state employment shocks are nearly a parallel shift in the state's yield curve. This is sensible if employment shocks have a long decay.

Moving to the ten-year yields, results are in Table 7.

Table 7: State Bond Yields, 10 year maturity

Dependent is State Bond Yield, 10 year maturity				
	Empl	ln(Empl)	Empl	ln(Empl)
coefficient	3.340e-08	-0.001627	1.044e-07	1.478e-03
t-stat	0.053	-0.275	0.145	0.313
state fixed effects	y	y	y	y
time dummies	n	n	y	y
Dependent is State Bond Yield minus Treasury, 10 year maturity				
	Empl	ln(Empl)	Empl	ln(Empl)
coefficient	-4.75e-05	-0.371376	-1.94e-06	-2.61e-02
t-stat	-21.713	-36.284	-2.185	-4.484
state fixed effects	y	y	y	y
time dummies	n	n	y	y

For 35 states with general-obligation bonds, monthly 2004-2012, dependent is state yield in top panel; state yield minus Treasury in bottom panel.

In each maturity specification we see the same pattern. There is generally no statistically significant relation between state yields and state employment levels; the relationship is revealed by taking the difference of state yields from Treasuries. For a range of Fed reaction functions, whether Taylor Rules or similar, Treasury yields are likely related to aggregate employment levels. This aggregate correlation swamps the individual differences that are revealed by looking at the spreads.

Adding lagged employment growth does not change the basic result: bond yields are not affected by employment while bond spreads are negatively related to employment growth. With a variety of lag specifications up to six months (although AIC and BIC indicate shorter lengths) the results are similar. Positive employment shocks cannot be shown to not Granger-cause decreases in the spread of state bond yields from Treasuries.

Splitting the sample before and after 2008 shows the same general pattern of signs; the negative impact of employment changes upon yields is statistically significant up to 2008 but without statistical significance in the later years.

Further Research

In examining the structure of state bond issuance, one question that rises to the front is, why is there a relatively limited number of capital instruments available to municipalities? (Robert Shiller,1998) has made this point in other contexts. Firms can issue debt, equity, and various combinations of those (convertibles, warrants, etc.). Would it be sensible for municipalities to issue some number of state-contingent securities, which could better span the relevant states of nature? For example, a state could issue a bond that would not make interest payments in any year when the state's employment fell. Although such bonds would have more uncertain cash flows to investors, they could help a state's fiscal position by lessening budgetary pressure at times when (due to exogenous economic shocks) the state's ability to pay is likely to be most limited. This is analogous to the state buying insurance against employment shocks.

Of course the issuance of such bonds would depend on the discount: if investors demanded a steep discount then states would be unwilling to buy insurance at such high rates. One goal of future research is to model the likely discount that current bond-pricing dynamics would imply.

Consider a sketch of such a bond. If the issuer were expected to skip a year's payment once during the twenty-year life of the bond then this would reduce the value of the bond by as much as 4% (if the skipped payment were the very first year) or as little as 1.5% (if the skipped payment were not for 20 years). The bonds would have a greater price volatility particularly as the duration lessened: a bond that matures in one year, that might skip the final year's interest payment, would not smoothly converge to a final price at maturity (as most valuation models assume) but would have a big discontinuous jump depending on whether the trigger were hit to skip a payment. Stripped coupons would be even more volatile. However this would allow investors to maintain exposure to state-specific risks and would open the range of instruments and "macro markets" that have been suggested by authors such as Robert Shiller. States would in turn receive information about market beliefs about their economic future.

In designing possible instruments, one consideration is paramount: the bonds must be structured so that the trigger is plausibly exogenous. State unemployment or job-creation rates are not only insensitive to current state policies but, in the US, are measured by an impartial federal agency. Other sovereign entities (e.g. Greece) would likely not be able to commit to similar triggers because the sovereign entity controls the very data collection. Sovereign issuers such as Greece and Argentina have already demonstrated a willingness to falsify economic statistics to hide budget woes. To issue such trigger bonds, a sovereign entity would need to find some statistic that is plausibly beyond its government's influence.

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