Fiscal Imbalances and Borrowing Costs: Evidence from State Investment Losses*

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Abstract

This paper examines the effects of losses in U.S. state pension funds on state borrowing costs. Since public-employee pension obligations are generally senior to state general obligation bonds, large increases in unfunded pension liabilities should be a concern for municipal bond investors. During the 3 months ending December 2008, losses in state pension funds amounted to between 1% and 6% of annual gross state product, and between 9% and 48% of annual state revenue, depending on the state. Using this cross-sectional variation, we find that over this period tax-adjusted municipal bond spreads rose by 10-20 basis points for each 1% of annual gross state product lost in pension funds by states in the lower half of the credit quality spectrum. A similar result holds for each 10% of annual state revenues lost. The effect is approximately constant over the yield curve, suggesting a constant upward shift in annual risk-neutral default probabilities. These results are robust to controls for credit ratings and other measures of the state's fiscal strength. They hold within credit rating categories and are strongest among states with the weakest ratings. We conclude that U.S. state borrowing costs will likely increase if unfunded state liabilities continue to grow, making state debt more expensive to finance.

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Fiscal imbalances in the U.S. have emerged at all levels of government. These imbalances have raised the question of how expensive it will be for governments to finance large deficits, should they persist in the future. At the national level, this debate manifest itself last year in public expressions of doubt by Chinese Prime Minister Wen Jiabao in the credit quality of U.S. Treasury bonds, and writings about the possible impact of this doubt on bond markets and the economy (Auerbach and Gale (2009), Feldstein (2009)). At the state and local level, analysts have voiced concerns about the credit quality of state and local municipal debt, whose spreads relative to Treasuries rose dramatically when monoline insurers suffered losses during the credit crisis (Roubini (2008)).

A great deal of literature in macroeconomics has focused on understanding the theoretical relation between deficits and interest rates. The literature arguing that deficits matter has focused on models in which deficits affect interest rates because they crowd out private savings, which reduces the capital stock (Modigliani (1961), Feldstein (1974)). In open economies, these effects are weaker. If Ricardian equivalence holds then they are absent (Barro (1989)). Empirical work that connects deficits and interest rates has also focused on this traditional channel (see Engen and Hubbard (2004), and Gale and Orszag (2004)).

In contrast, relatively little research has attempted to estimate the effects of fiscal imbalances on borrowing costs through the channel of higher probabilities of default. This "sovereign default" channel is narrower, given that it is about national or state borrowing costs, and therefore only indirectly about macroeconomic interest rates. These higher borrowing costs are important, however, as they require that more taxpayer money is dedicated to servicing debt, and (as pointed out by Goolsbee (2007)) tie the hands of government if it needs to borrow further in times of crisis.

Until recently, this default channel was viewed as essentially implausible in developed countries. As a result, empirical work on the impact of deficits on the economy has largely focused on time-series analysis. It has faced the challenge of measuring market projections of future federal debt and deficits, as these projections will affect current equilibrium borrowing rates. Furthermore, it is difficult to find cross-sectional variation that is useful for disentangling the simultaneous relationship between government actions and economic variables.

This paper attempts to fill this gap by examining variation across U.S. states in the extent and importance of state-sponsored pension fund investment losses during the last quarter of 2008. When a U.S. state suffers an investment loss in a state-sponsored pension fund, the increased underfunding represents an increase in an unfunded state liability. Given the protections that state constitutions offer to the pensions of public employees, these liabilities are generally at least as senior as state general obligation bonds (Brown and Wilcox (2009)). As a result, each dollar lost in an underfunded state pension fund represents an additional dollar of senior unsecured debt above the state's (effectively junior) general obligation debt.

We find that for each 1% of annual gross state product lost in pension funds during this period, tax-adjusted municipal bond spreads were higher by approximately 10 basis points for states rated AA, and by approximately 20 basis points for states rated AA– and below. Analogous results hold when the losses are scaled by state revenue. For each 10% of revenue lost, spreads rose by approximately 10 basis points for states rated AA, and by approximately 20 basis points for states rated AA– and below. States rated AA, AA–, or below constitute approximately half of our sample. Consistent with our hypotheses, we find no effect of the losses in the states in the half of our sample that have ratings better than AA.

The amount of money lost in state public-employee pension funds during this quarter was substantial relative to the amount of state municipal debt outstanding. In the last quarter of 2008 alone, we estimate that assets in pension funds sponsored by U.S. states fell in value by approximately $400 billion. This amount is approximately 42% of the $940 billion in total outstanding state municipal bond debt (i.e. their on-balance-sheet debt). As a result, during this 3-month period, state municipal bond investors as a group effectively faced the appearance in the state's debt structure of a new, senior, off-balance-sheet debt equal to 42% of their existing positions. Novy-Marx and Rauh (2009) calculate that as of December 2008, total unfunded pension liabilities under proper accounting were 3.5 times larger than state municipal debt on the balance sheet. As reviewed in Novy-Marx and Rauh (2010), these pension promises were already deeply underfunded even before the financial crisis.

Importantly, there was substantial cross-sectional variation in the development of the underfunding of pension liabilities across states during the last quarter of 2008. For example, Tennessee lost the smallest percentage of gross state product (GSP) at 1.4%, and West Virginia lost the smallest percentage of annual state non-investment revenue at 8.7%. In contrast, Arkansas lost 5.6% of GSP and Ohio lost 47.7% of annual state non-investment revenue. As a percentage of tax revenue (that is, excluding intergovernmental revenue and charges for state services), Ohio's loss was more than 100% — the state lost more in the investment fund in 2008Q4 than it had collected in tax revenue in all of 2007.

Merely observing that municipal bond spreads rose in aggregate during this period would not allow us to conclude that the increase in spreads, and hence state borrowing costs, is due to this effect. Many other events were happening simultaneously, including a flight to the quality and liquidity of Treasury bonds and a general deterioration of state and federal public finances. Comparing the change in spreads between the states that were not as affected by the pension fund losses and the states that were more affected allows us to eliminate these macroeconomic effects.

The state-level variation comes from three sources: 1.) differences in the size of the state employee pension funds relative to the state's economy or revenue base, 2.) differences in the extent to which those promises were funded as of September 2008, and 3.) differences in the asset allocation pursued by the state funds. States with larger total pension liabilities relative to their economies or revenue bases, states that have larger funding ratios for a given liability, and states that took greater risk with those assets were therefore more exposed. Importantly, our results are robust to controlling for credit ratings and for the size of state pension liabilities. The results are therefore not driven by the possibility that states that sponsor large public-employee pension plans suffered larger declines in creditworthiness during this period for other reasons (e.g., because the market viewed them as more fiscally profligate on other dimensions).

A further concern we address is the possibility that states that suffered large losses relative to their economies and revenue streams might also be the states for which revenue is the most cyclical. This cyclicality might cause the municipal market to punish these states more in a recession. Standard risk management theory suggests this explanation is unlikely, as states with more pro-cyclical revenues should have been more cautious in their investment strategies. Regardless, the results are also robust to controlling for the historical sensitivity of state revenues to gross state product, measured over 1992-2007.

Our analysis is based on pricing data from 15,727 municipal bonds, from which we calculate yields based on bond characteristics. Two important technical issues are the treatment of call features in the bonds and the treatment of the fact that the interest on the bonds is tax exempt. To address the fact that many bonds in our sample are callable, we option-adjust the yield spreads we employ in our regression, so that these reflect states' true fixed-rate borrowing costs over horizons equal to the bonds' durations, and not the costs of states maintaining refinancing rights.

To address the tax issue, we gross up the yields based broadly on the findings of Poterba and Verdugo (2008), with the result being that our main coefficients are higher by approximately the magnitude of $(1/(1-\tau))$ than they would be if we ignored the tax subsidy provided by the government. The use of tax-adjusted yields means that our results reflect the total cost of state borrowing, including the subsidy provided by the U.S. government. Our main dependent variable is the change in the spread of the tax-adjusted yield over Treasury bonds of comparable duration. We note that since we are examining changes, the results are very similar if we consider changes in yields instead of changes in yield spreads.

Our analysis also has implications for the effects of these state losses on the risk-neutral default probabilities and recovery rates implied in municipal bond prices. As illustrated by Duffie and Singleton (1999), changes in bond spreads can be due to: 1.) changes in actual default probabilities; 2.) changes in the price of a contingent claim in the default state of the world (the "state prices"); or 3.) changes in the market's estimation of recovery rates if the borrower defaults. If recovery rates in default were unchanged, our yield spread results could be interpreted as revealing the increase in risk-neutral (or "subjective") default probabilities, which incorporates both active probabilities and state prices. For example, for each 1% of annual gross state product (or 10% of state revenues) lost during this period, the 10-20 basis point increase in the yield spread would be consistent with a 10-20 basis point increase in risk-neutral annual default probabilities assuming no recovery in default, or a 20-40 basis point increase in risk-neutral annual default probabilities assuming the market expected a 50 percent recovery rate in default.

Given that state revenues are pro-cyclical, our analysis also highlights the fact that by investing pension funds in equities, states experience increased borrowing costs under exactly those conditions when their tax base is decreasing, i.e., in recessions and at times when the stock market performs poorly. Analysis of optimal state pension fund investment policy starts from the premise that if citizens can (and do) undo the investment decisions made by states, then pension fund investment policy is not relevant for social welfare (see for example Lucas and Zeldes (2009)). However, the correlation we find between poor asset performance and higher borrowing costs represents an additional reason why state public pension fund investment policy might have welfare implications.

The magnitude of losses during the event period we study is only modestly large. A loss of even 50% of a year's tax revenue is not likely to be catastrophic for a solvent state. However, the magnitude of the effect of these losses on yield spreads indicates that prices in the market for state municipal bonds do at least to some degree reflect default probabilities. U.S. state borrowing costs will likely increase if unfunded state liabilities continue to grow, making state debt more expensive to finance. We note that if an increased borrowing cost exactly matches the increase in the state's valuable option to default, then states might not care that they face higher borrowing rates. However, to the extent that the state bears costs of financial distress in the event of a default, the default option may well be more of a concern to markets than it is a value to the state.

This paper proceeds as follows. Section 1 explains relevant institutions in the municipal bond market and state pensions, and it reviews relevant literature. Section 2 describes the data. Section 3 explains how we calculate option-adjusted and tax-adjusted yields from bond pricing data; these yields reflect states' true fixed-rate borrowing costs and serve as our main dependent variables. Section 4 discusses the main results. Section 5 concludes.

1. Institutional Background and Literature Review

The main objective of this paper is to measure and interpret the change in municipal bond yields that results when state sponsors suffer large investment losses. As such, there are three areas where an explanation of existing literature and institutional details are required: the market for municipal (and sovereign) debt, state-sponsored pension funds, and the consequences of government fiscal imbalances.

A.) Municipal Bond Markets

Municipal bonds are bonds issued by sub-national government entities, including U.S. states. Municipal bonds may be general obligation (GO) bonds, in which case the proceeds may be used for any purpose and the obligation is backed by the obligor's ability to levy taxes. Alternatively, they may be revenue bonds, in which case they are secured by revenues from a specific enterprise.

The primary distinction in the modern era between municipal bonds and sovereign bonds, which are issued by countries, is that issuers of municipal finance do not have the ability to control the circulation of the currency in which their debt is denominated. Sovereign entities can effectively repudiate debt denominated in local currency by allowing inflation; and since national governments also typically control statistical offices, there is even sometimes scope for manipulating indices that underlie inflation-indexed debt. States and municipalities, in contrast, do not have the capacity to "inflate away" their debts, although such debts do fall in value if inflation happens on a national scale.

The last state default to occur was Arkansas during the Great Depression in the 1930s (Litvack (1999)). The most significant round of repudiation of state indebtedness happened following the extreme circumstances of the Civil War, in which at least 13 states defaulted (Spiotto (2008)). While institutions such as credit rating agencies and municipal bond insurance have developed since these times for the purposes of protecting investors, occasional county and city-level defaults (such as Orange County, California in 1994) and the recent financial crisis have exposed the limits of the protections these institutions afford. As a result, some of the default considerations that have arisen in the literature on sovereign defaults may now be relevant for municipal bonds.

The literature on municipal bonds has focused on the impact of their tax treatment on their prices and yields. Interest on U.S. municipal bonds is exempt from federal taxation as long as the bonds meet certain legal requirements. Bonds that are not tax exempt include those for certain private activities, as well as those designed to take advantage of arbitrage profits by buying Treasuries. Finance theory going back to Miller (1977) has posited that after-tax yields from comparable taxable and tax-exempt bonds should only differ by the tax rate of the marginal municipal bond investor. A large literature has attempted to measure the tax rate implicit in municipal bonds.

One fact that comes out of this literature is that the yields on long-term tax-exempt debt were historically quite high relative to the yields on long-term Treasury bonds, apparently higher than could be explained simply by the multiplicative effect of tax rates in the model of Miller (1977). Trzcinka (1982) and other authors have ascribed this "municipal bond puzzle" to the idea that municipal default risk may be higher than that of U.S. Treasury bonds, even though close to half of municipal bonds are protected by monoline insurance (Nanda and Singh (2004)). In contrast, Chalmers (1998) shows that the puzzle is still present among bonds which have been pre-refunded. When a bond is pre-refunded (or "advance refunded"), new securities are issued and the proceeds are invested in Treasuries and placed in an escrow account to defease the existing obligation.[1] Furthermore, many municipal bonds are callable by the issuer, and pre-refunding bonds to a certain maturity date (usually the first call date) eliminates the uncertainty about when the principal will be repaid. Municipal bonds may differ from each other and from Treasuries in their liquidity, which is a leading hypothesis for the "muni puzzle".[2]

This literature highlights three important points for the purpose of our analysis. First, there may be substantial heterogeneity among municipal bonds in the degree to which their promises are secured by specific projects. As a result, we will limit our analysis to general obligation municipal bonds which are unsecured. Second, the fact that many municipal bonds are callable requires them to be viewed as a package of a straight bond and a short call option (held by the state). These considerations will affect the computations of yields and spreads for callable bonds. Third, prerefunded municipal bond spreads

[1] Pre-refunding is thus a mechanism by which states can take advantage of falling borrowing costs or can effectively call bonds before their call dates. Tax law generally allows issuers to invest the proceeds at any yield that is as high as the municipal yield, though not higher (Wood (2008)). Such a transaction was common when Treasury yields were above municipal yields — by using bonds of different maturities states could match the received muni yield with the Treasury bond yield and thus refinance before the call date.

[2] There are many other attempts to derive implicit marginal tax rates in the muni market. Green (1993) explains the muni puzzle with a model in which investors optimally choose portfolios with offsetting investment interest expense, so that the taxable part of their bond portfolio is not taxable. Longstaff (2009) uses an affine term-structure approach to derive an average marginal tax rate for municipal investors of 41.6%. Ang, Bhansali, and Xing (2008) show that comparing trades in bonds with varying degrees of market discount can lead to implicit tax rates of close to 100%.

are very unlikely to reflect default risk. While the risk of legislative action that affects these investments could affect the prices of pre-refunded issues, default risk does not. Therefore, the difference in yields and performance between municipal bonds that are pre-refunded (ultimately about 16% of our sample) and those that are not may provide information about the possibility of municipal defaults.

An additional consideration is the existence of heterogeneity in the degree to which municipal bonds are insured. Anecdotally, market participants became wary of the value of this insurance during late 2008, due to increasing concerns about counterparty risk. We observe whether the bonds in our sample are insured or not, and we examine the extent to which the insurance protected bond value in the face of state investment losses.

B.) State Pension Funds

In a typical defined benefit (DB) pension plan, an employer pledges an annual pension payment that is a function of the employee's final salary and years of employment. Most states have at least one DB plan for teachers and another for general state employees. Some states have one combined plan for all state employees. Many have a number of smaller plans.

While the US corporate sector has moved away from DB plans and towards defined contribution (DC) arrangements such as 401(k) plans, the public sector has seen very limited movement in this direction. A March 2008 Bureau of Labor Statistics (BLS) survey indicates that 80% of state and local government workers are enrolled in a DB plan and under 20% are enrolled in a DC plan (Bureau of Labor Statistics (2008)). The GAO in late 2007 reported that only Alaska and Michigan offered new employees in their "primary pension plan" a DC arrangement but not a DB arrangement, while Indiana and Oregon offered a hybrid plan; all other states offered only DB plans to new employees in their primary plan (Government Accounting Office (2007)). Finally, according to data from the Pensions and Investments (P&I) survey of the 1000 largest pension plans, 32 states reported nonzero defined contribution (DC) assets in a state-sponsored pension plan. However, the total magnitude of DC assets was $83 billion, compared to $2.3 trillion in DB assets.

How does the value of these DB assets ($2.3 trillion) compare to the present value of states' pension liabilities? Just as future Social Security and Medicare liabilities do not appear in the headline numbers of the U.S. federal debt, the financial liability from underfunded public pensions does not appear in the headline numbers of state debt. Government pension accounting should ideally provide citizens and government officials with a sense of how indebted taxpayers are to state employees. If pensions are underfunded, then the gap between pension assets and liabilities is off-balance-sheet government debt.

However, government accounting rules currently obscure the true extent of public pension underfunding. In particular, Government Accounting Standards Board (GASB) ruling 25 and Actuarial Standards of Practice (ASOP) item 27 stipulate that public pension liabilities are to be discounted at the expected rate of return on pension assets. This procedure creates a major potential bias in the measurement of public pension liabilities. Discounting liabilities at an expected rate of return on the assets in the plan runs counter to the entire logic of financial economics: financial streams of payment should be discounted at a rate that reflects their risk (Modigliani and Miller (1958)), and in particular their covariance with priced risks (Treynor (1961), Sharpe (1964), Lintner (1965)). In practice, state actuaries discount all cash flows promised under pension plans at a rate of 8%.

In a recent study, Novy-Marx and Rauh (2009) found that while total state pension liabilities under state government reporting were $3.0 trillion at the end of 2008, using a correct discounting procedure reveals that they are dramatically larger. We considered two discount rate candidates for a given pension-related cash flow: 1.) the yield on a zero-coupon state GO municipal bond with the same term as the payment, grossed up to eliminate the tax preference given to borrowing; and 2.) a zero-coupon Treasury rate with the same term as the cash flow in question. The muni-based rate would be appropriate from the perspective of taxpayers who thought that the state could default on its pension obligations under the same circumstances as it would on its general obligations. While in some states this may be appropriate, most states contain constitutional guarantees that effectively place state pension obligations senior to general obligations in the state's debt structure (Brown and Wilcox (2009)).[3]

The Treasury-based rate may be appropriate as a default-free rate. However, Treasury rates include an inflation-risk premium (Fisher (1975), Barro (1976)), which is generally positive, and likely additionally contain a liquidity discount (Duffie and Singleton (1997), Longstaff (2004), Krishnamurthy and Vissing-Jorgensen (2008)). The liquidity concerns would argue for using rates higher than Treasury

[3] Brown and Wilcox (2009) conclude that states offering a constitutional guarantee make up a "clear majority". They highlight the 8 states with the most protections (Alaska, Arizona, Hawaii, Illinois, Louisiana, Michigan, and New York, and New Mexico) and the 2 states with the rules offering the fewest protections (Indiana and Delaware). However, the true stance of many states in the middle may not yet have been tested through cases, so that variation in these protections does not represent a useful source of identifying variation for our tests. The results are in any case robust to the exclusion of Delaware, which carries a AAA rating. Indiana does not issue long-term general obligation municipal bonds.

bonds, while the inflation effects would argue for using lower rates, since state projections of payments almost always contain cost of living adjustments.

Discounting using taxable municipal bond rates, which reflect states borrowing costs, yields total state liabilities of $3.3 trillion, and unfunded liabilities of $1.3 trillion (Novy-Marx and Rauh (2009)). Discounting using Treasury rates yields total state liabilities of $5.2 trillion, and unfunded liabilities of $3.2 trillion. A further reason to view these pension liabilities as very safe is that the figures are based solely on payments that have already been promised and accrued. In other words, even if the pension plans could be completely frozen, states would still contractually owe these benefits. A substantial fraction of liabilities are due to former state workers who are already retired.

Given the relative seniority of public-employee pension obligations, increases in unfunded pension liabilities are a serious concern for municipal bond investors.

C.) Fiscal Imbalances, Interest Rates, and Borrowing Costs

As mentioned previously, most literature on the effects of deficits on interest rates have focused on a macroeconomic channel by which government borrowing crowds out private investment. This study is examining a different channel by which deficits matter, namely that they raise government borrowing costs. Higher borrowing costs require more taxpayer money to be dedicated to servicing the debt, and they tie the hands of government if it needs to borrow further in times of crisis.

The literature examining the macroeconomic channel is large. Engen and Hubbard (2004) and Gale and Orszag (2004) provide reviews and recent evidence. One of the primary challenges is measuring innovations in government policy that are not foreseen by markets (Plosser (1982, 1987)).

This paper also relates to a literature on state public finances and how they affect state borrowing costs. Again, the challenge is measurement of innovations in state government policy. Poterba and Rueben (2001) find that unexpected state deficits were correlated with higher state bond yields during the 1990s, though this effect was smaller for states with tight balanced-budget rules. Poterba (1994) shows that these budgetary institutions are also important determinants of state responses to fiscal crises. Unfunded pension liabilities are off of the states' balance sheets and have only an indirect effect on the state's budgetary income statement, through imputed revenues from and expenditures on employee retirement funds. The imputed revenues primarily consist of investment gains plus contributions from employers other than the state entity, and the imputed expenditures are essentially benefit payments to beneficiaries.[4]

2. Data and Summary Statistics

This section describes the data and presents summary statistics. We also show raw correlations between municipal bond returns and state investment losses.

A.) Data

For municipal bond data, we use two main sources. The first source is the S&P Municipal Bond CUSIP Master File. This file contains CUSIP identifiers, and the attributes file allows us to determine which bonds are issued by states as opposed to municipalities, as well as which bonds are general obligation and which bonds are revenue bonds. We retain only state-issued general obligation bonds that are unsecured and mature in 2008 or later. These bonds represent the grand majority of total value in the muni portion of the CUSIP master file.

From Bloomberg we download the rest of the bond attributes: whether the bond is insured and if so by which monocline insurer, the size of the issue, whether the bond is callable, call price, first call date, whether the bond is pre-refunded and if so at what price and to what maturity date. From Bloomberg, we also took the price of each bond as of September 30, 2008 and as of December 31, 2008. The final sample is 15,727 bonds that were outstanding during this entire time period. These bonds represent a total of $707 billion in value.[5]

Figure 1 gives a general overview of the entire municipal bond market during this period. These graphs are based on Bloomberg aggregates and, unlike our sample, are not limited to state general obligation bonds.[6] The top graph shows yield spreads on September 30th for A-, A+, AA+, and AAA rated municipal bonds. Spreads at the short end of the curve ran from around 0.5 percentage points for AAA bonds to around 1 percentage point for A- bonds. Spreads were somewhat smaller at less than a 10-year horizon. At a 15-year horizon they are similar to the short-horizon spreads. At a 30-year horizon, spreads were around 0.9 percentage points for AAA bonds and 1.6 percentage points for A- bonds.

The middle graph shows the December 31st spreads, which requires a much broader scale on the vertical axis. While very short-horizon spreads remained about where they were on September 30th,

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[4] See http://www.census.gov/govs/www/06classificationmanual/chapter04.html for further details.
[5] This total is consistent with disclosures by the U.S. Census Bureau suggesting that states have around $300 billion in public debt for specific private purposes for a total of approximately $1 trillion in debt outstanding.
[6] In fact, the lowest state level credit rating at the time was A.

the rest of the yield curve shifted dramatically upwards for all credit rating categories. The bottom graph shows this change in yield spreads. An important point illustrated by the bottom graph is that spreads on municipal bonds of all credit ratings increased substantially. Spreads in the 5-10 year range increased by about 1 percentage point, while spreads in the 10-30 year range increased by about 1.5 percentage points. To a large extent this reflects what was happening in the Treasury market, as investors fled to the safety and liquidity of U.S. Treasury bonds.

For data on state public finances, we use data from two main sources. First, the U.S. Census Bureau database of state and local government finances provides current and historical information on state revenues. State revenue can broadly be decomposed into: i.) tax revenues, ii.) inter-governmental revenues (such as transfers from the federal government), iii.) charges levied for the use of state services (e.g. tuition at state universities, airport fees, etc), and iv.) revenues the state imputes as arising from the investment returns of trust funds such as its pension funds. In this paper, we refer to state revenue or total revenue (interchangeably) as the sum of taxes (i), inter-governmental revenue (ii), and charges (iii). We exclude pension fund investment revenue from this total, as including it would generate a mechanical correlation between state revenues and our identifying source of variation.[7] Second, we use data from the Bureau of Economic Analysis for current and historical information on state economic activity and gross state product.

For state pension assets and asset allocation as of September 30, 2008, we use *Pensions and Investments* (P&I) survey of the 1000 largest pension plans. The latest survey, published in January 2009, contained data for September 30, 2008 on all plans. The P&I asset allocation data decomposes assets into 9 categories: Domestic Stock, International Stock, Domestic Fixed Income, International Fixed Income, Cash and Equivalents, Private Equity, Real Estate Equity, Mortgages, and Other. Using the database of state pension fund reports compiled by Novy-Marx and Rauh (2009, 2010), we check the quality of these reported asset allocations and find them consistent. The state reports themselves have the disadvantage of not all being harmonized to the same date, which is why we use the P&I data, but calculations based on the reports yield very similar results

To estimate returns during this period, we use return indices for the pension fund asset classes from September 2008 through December 2008. These were collected from the Kenneth R. French Data Library (the Fama-French factors), Barra MSCI, and Lehman Brothers / Barclays. States do not typically report quarterly asset levels, making this estimation necessary. This method also has the advantage that

[7] Also, the results in this paper are robust to scaling by tax revenue instead of total revenue. Since tax revenue is about half of total revenue excluding trust fund revenues, the magnitudes of the coefficients on tax revenue are about twice as large as the ones we report based on total revenue.

if states do engage in home bias in their public pension fund investing, it is preferable to use estimated returns based on asset classes than realized returns, as the realized returns in a home-oriented portfolio could generate a mechanical correlation between pension returns and muni yield changes.[8] Appendix Table 1 shows these returns for all state investment funds included in the *Pensions and Investments* survey. There were 71 such funds, covering 116 plans across 50 states.[9]

For pension liabilities, we use the database constructed from Comprehensive Annual Financial Reports (CAFRs) described in Novy-Marx and Rauh (2009, 2010). In that study, we examined the most recent Comprehensive Annual Financial Report (CAFR) for each pension plan and collected total actuarial liabilities for each pension plan, along with the discount rate used by state actuaries to calculate these liabilities. The data also contain our present value measures of already-promised state pension liabilities using discount rates that reflect their risk.

B.) Summary Statistics

Tables 1 and 2 present summary statistics on the bonds and the state-level variables respectively. The median bond matures in 2017 and has a coupon of 5%. 32% of the bonds are insured, 16% were pre-refunded by the end of the sample period, and 61% were callable. The mean holding-period return on these bonds was 0.9%. The mean duration of the payments (ignoring call features) was 5.8 years.[10]

Section 3 explains in detail how we calculate yields and yield spreads from bond prices, taking the call features of the bonds into account. The mean yield spread for a bond in our sample was 0.6 percentage points on September 30, 2008, and rose to 1.7 percentage points on December 31, 2008. We tax-adjust these yields based broadly on the findings of Poterba and Verdugo (2008), by grossing up the yields by 25%. Poterba and Verdugo (2008) document that over the 10 years from 1998-2007 the spread of Treasuries over municipal bonds has been in the range of 50bp to 139bp, representing an implicit tax rate of between 14.9% and 30.0%. Over the period from 1991 to December 2008, the average implicit tax rate was 26.3%, and over 1997-2008 it was even lower. Their analysis assumes the

[8] For example, Massachusetts has mandated since 1983 that the pension fund should make investments "as much as reasonably possible to benefit and expand the economic climate within the Commonwealth." These incentives were strengthened by a 2003 policy on Economically Targeted Investment or ETI (Hagerman, Clark, and Hebb (2006)). The Washington State Investment Board adopted an ETI policy in 2003.

[9] Again, most states have at least one DB plan for teachers and another for general state employees, which explains why the number of plans is larger than the number of states. The plans are sometimes consolidated into one investment fund.

[10] If we calculate the duration of the tradable bond, accounting for the option feature, we find that the returns on duration-matched Treasury bonds were 7.9%, for an excess return of -7.0%.

market believed municipal bonds were no more likely to default than Treasuries, an assumption that is clearly violated today. During our sample period, Treasuries traded at a premium to AAA municipal bonds. Our assumption is therefore equivalent to the notion that during the Poterba and Verdugo (2008) period, the default probabilities for AAA municipals equaled the default probability for Treasuries, even though that is no longer the case today.

The effect of adjusting the yield spreads upwards by 25% for taxes is essentially to raise the coefficients by 1/(1-25%) or 4/3rds. Some authors conclude that the marginal investor in municipal bonds has much higher tax rates. In particular, Longstaff (2009) derives a rate of 41.6% based on an affine term-structure model, and Ang, Bansali and Xing (2008) find rates of 75% or even 100% based on the trades of market participants in market-discount bonds. To the extent that the marginal tax rate is even higher than 25%, our estimates understate the true increase in the cost of borrowing to states. If one wanted to consider only the cost realized by the state government and excluding any federal subsidy, the tax adjustment could be set to zero.

The change in the tax-adjusted yield spread over this period was an increase of 0.86 percentage points at the mean and 1.05 at the median. This was completely due to the bonds that were not pre-refunded (84% of our sample), as the pre-refunded bonds on average showed negligible changes in their spread to Treasuries.

Table 2 shows state-level fiscal and pension summary statistics. There are 39 states that both sponsor pension plans and have nontrivial amounts of traded general obligation debt. These states had average 2007 tax revenue of $17 billion and average 2007 total revenue of $34 billion. Their debt outstanding at the end of 2007 was $22 billion. Their average gross state product (GSP) was $315 billion, so that a typical year of revenue is about 10% of GSP.

States lost substantial amounts in their investment funds during the last quarter of 2008. In dollar terms, the average loss was $8 billion during these three months. This is an average of 2.5% of GSP, 21% of total revenue, and 39% of the total value of the state's outstanding balance-sheet debt. One cross-sectional standard deviation of the loss amounted to $12 billion, or 1% of GSP, or 9% of state revenue.

3. Calculating Yields and Borrowing Costs

To determine the effects on borrowing costs, we must calculate yields that take the option features (callability) of the bonds into account. This section explains these calculations.

Most municipal bonds (more than 61 percent of our sample) are callable. Owning a callable bond is like owning a non-callable bond and being short a call on the bond, so callable bonds are cheaper than non-callable bonds, *ceteris paribus,* and consequently pay higher yields. These higher yields do not reflect higher fixed-rate borrowing costs, but are the cost of the states' refinancing option. States' true fixed-rate borrowing costs are consequently more accurately reflected by option-adjusted bond yields, *i.e.,* yields on "synthetic" non-callable bonds, constructed by adding the calls back to the callable bonds.

Roughly 30 percent of the callable bonds in our sample have been pre-refunded. These bonds are typically secured by an escrow account holding a replicating portfolio of U.S. Treasury securities, which will pay off the bond on the first call date. Consequently, while technically callable these bonds are effectively non-callable, maturing on their pre-refund dates with face values equal to their call prices (which for roughly 30 percent of the pre-refunded bonds exceeds their face values).

For the non-prerefunded callable bonds (roughly 44 percent of our total sample), calculating an option-adjusted yield requires that we calculate an option-free bond price. That is, the price of the "synthetic" non-callable bond is constructed by adding the call back to the callable bond. The call embedded in a callable bond can be valued as a receiver swaption. A swaption is an option to take a position in an interest-rate swap agreement at some date in the future, where the swap's fixed rate is specified in the swaption contract. The state can force bond holders to deliver their fixed coupon bonds in exchange for a lump-sum payment, usually par. Because a bond newly issued at the swap rate trades at par, this is equivalent to forcing the bond holders to exchange a stream of fixed payments (the bond's coupons) for a different, currently unknown, stream of fixed payments (the future swap rate). Options of this sort are typically valued using Black's model for options on futures (see Appendix for details). The implicit assumption is that the future swap rate is log-normally distributed around its current level. Bloomberg provides swaption prices, quoted in Black volatilities (*i.e.,* the implied volatility of the future swap rate), for expiration dates out to ten years written on swaps with up to ten years maturity at option expiration. The implied volatility surface interpolated from this matrix can be used, with Black's model, to calculate the value of a swaption with any time to expiration and tenor.[11]

For each callable bond, we calculate its option-free price by summing 1) the bond's price obtained from Bloomberg, and 2) the price of the receiver swaption struck at the bond's coupon rate,

[11] Our prices are for swaptions written on US dollar LIBOR, and we consequently have the volatility surface for LIBOR swap rates. We employ it here as the best available proxy for the volatility surface for muni swap rates.

expiring on the bond's first call date, with a tenor equal to the call's remaining maturity at expiry. We then add back accrued interest, which is not included in the quoted prices. Under market conventions, quoted prices do not include any interest that has accrued since the last coupon date, which the bond purchaser is required to buy at the time of purchase.

A bond's option-free yield is then calculated as the single discount rate that when used to discount all the bond's payments yields the bond's price (option-adjusted and including accrued interest). The yield spread is the difference between the bond's yield and the yield on a treasury security with the same duration.

Duration and Convexity

The price of an option-free bond (*i.e.,* a non-callable bond, or an option-adjusted callable bond) is given by

$$P = \sum_i \frac{c/2}{(1+y/2)^{2t_i}} + \frac{F}{(1+y/2)^{2T}} ,$$

where t_i are the times until coupons are paid, T is the time until principle is repaid, y is the bond's yield (annualized with semi-annual compounding), c is the coupon rate, and F is the face value (or for pre-refunded bonds, price at which issue is pre-refunded). The duration of an option-free bond is the value-weighted average time at which the bond coupons and principle are paid,

$$D = \frac{1}{P}\left(\sum_i \frac{t_i c/2}{(1+y/2)^{2t_i}} + \frac{TF}{(1+y/2)^{2T}}\right).$$

The convexity is the value-weighted squared average time of the bond's payments:

$$C = \frac{1}{P}\left(\sum_i \frac{t_i^2 c/2}{(1+y/2)^{2t_i}} + \frac{T^2 F}{(1+y/2)^{2T}}\right).$$

Note that these are simply the duration and convexity of a non-callable bond and are appropriate for use with the option-adjusted yield spreads, which are calculated using the synthetic option-free bonds.[12]

Excess Returns

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[12] The duration of a *callable* bond is the value-weighted average duration of the underlying option-free bond and the embedded call,

$$D_{callable\ bond} = D_{noncallable\ bond} + w(D_{noncallable\ bond} - D_{call}),$$

where $w = P_{call} / P_{callable\ bond}$. A completely analogous relation holds for convexity. For each callable bond the duration and convexity of the call can be calculated numerically, using Black's formula, assuming a parallel shift of the yield curve. As shown in Table 1, the mean duration of the bonds in our sample, treating them as option-free, was 5.8 years. The mean duration of the tradable bonds, some of which are callable, is shorter at 5.2 years, as the investors receive their cash earlier whenever a state exercises its call option.

The municipal bond returns we employ are simply the change in the quoted prices of the tradable bonds. These prices are not adjusted for call features, and are "clean," in that they do not include interest accrued from the previous coupon date. Municipal bonds' excess returns are calculated by subtracting from each bond's return the return to a duration-matched Treasury security (i.e., a Treasury with the same duration as the traded municipal bond).

The Term Structure of Defaultable Bonds

Duffie and Singleton (1999) show that, under the appropriate technical conditions, the market value of a defaultable claim to a dollar that will be paid *T* in the future, is given by

$$E^Q\left[\exp\left(-\int_0^T (r_t + h_t L_t + l_t)dt\right)\right]$$

where E^Q denotes the risk-neutral expectation, r_t is the short term interest rate process, and h_t, L_t and l_t are the *t* ahead hazard rate for default, expected fractional loss given default and liquidity carrying cost, respectively. That is, a defaultable claim should be discounted using a cumulative adjusted short-rate, where this adjusted short-rate accounts for both the time-value of money, r_t, and the "short-spread," $s_t = h_t L_t + l_t$, which reflects the total risk and liquidity adjusted mean-loss rate.

Changes in yield spreads therefore reflect changes in the average expected short-spread over a bond's life, and thus reflect changes in the expected default rate, the expected recovery rates given default, and the expected carrying cost of illiquidity. For example, assuming a fixed recovery rate given default of 50 percent and a fixed one percent annual cost of illiquidity, an increase in a bond's yield spread over treasuries of one percent implies an increase in the risk-neutral hazard rate of default of two percent per year.

4. Discussion of Results

This section discusses the main results. First, we examine bivariate correlations that are suggestive of a link between pension fund investment returns and changes in municipal bond spreads. We then move to multivariate regression analysis to add controls and consider interaction effects.

Figure 2 shows raw correlations between average state muni bond returns and the estimated losses suffered by the state’s pension funds during the period 9/30/2008-12/31/2008. Figure 3 shows raw correlations between average changes in state muni bond spreads and the estimated losses suffered by the state’s pension funds during the period. Only the 7,947 bonds that are not pre-refunded and that mature in 5 years or greater are included.

In both Figure 2 and Figure 3, the graphs differ in the horizontal axis, showing: i.) the share of pension fund assets in equity and real estate; ii.) the estimated pension fund percentage loss in 2008Q4; iii.) the level of state pension assets as a share of state government revenue; and iv.) the estimated value lost in the pension fund as a percentage of state government revenue. The bond returns and spread changes are value-weighted within states. The solid line represents a fitted linear relation in which all states are weighted equally. The dashed line weights the states by the amount of debt outstanding. The dotted line shows the unweighted linear relation excluding California, in order to address the concern that California may be an influential outlier.[13]

Equity and real estate are the categories that ex post lost substantially more in value than the fixed income categories. Across states, the mean of this variable is 67% and the standard deviation 7.5%. Taken literally, the top left graph of Figure 2 implies that for each additional percentage point of state assets allocated to equity and real estate as of September 30, 2008, municipal bond investors realized an additional loss of 10 basis points. Weighting by debt outstanding this effect was 20 basis points. Unweighted and excluding California, this effect was 6 basis points. In all cases the effect is statistically significant. The analogous graph in Figure 3 implies that for a one standard-deviation (7.5 percentage point) increase in state assets allocated to equity and real estate as of September 30, 2008, municipal bond investors saw spreads increase by 10 (=1.36*7.5), 20 (=2.63*7.5), or 7 (=0.93*7.5 basis points respectively), depending on the weights used and the treatment of California. The upper left graphs of Figures 2 and 3 therefore illustrate one of the reduced form relationships present in the data: states that were taking more risk in pension funds at the beginning of this period saw their muni spreads increase by more during this period than states that were taking lest risk.

The upper right graphs of Figures 2 and 3 move from considering risk allocation to considering the estimated return. Since the estimated return is a linear function of the allocation to risky assets, the conclusions from this graph are very similar. In unweighted regressions, for each additional percentage point of pension asset value lost, muni returns were 36 basis points lower and spreads increased by 5 basis points more.

The lower left graphs of Figures 2 and 3 shows another reduced form relationship, namely the one between the level of pension fund assets (as a share of government revenue) and the performance

[13] We also address this in Section 4 by highlighting the fact that the regression results are strongly significant within both the A to AA– ratings category (which includes California) and the AA category (which does not include California but which includes almost half of the states in the sample). Consistent with our hypotheses, the magnitude of the effect in the regressions is largest in the A to AA– category (20 basis points), strong in the AA category (10 basis points), and absent in the remaining category (AA+ and above).

of the muni bonds. Other things equal, we should have seen states with more investable assets to lose perform worse during this period. We find that this is roughly the case. Although the relationship is weak, it is clearly upward sloping. This is the opposite of what one would expect if our result were simply picking up variation in rich states versus poor states, and is consistent with the idea that states that lost more in their investment funds were punished more by municipal bond markets.

The graphs in the lower right put the effects together and show the relation between the value lost in the pension fund as a share of state government revenue and the change in the yield spreads on the state municipal bonds. Taken literally, these graphs imply (in unweighted regressions) that for each additional 10% of state revenue lost in pension funds, muni returns were 88 (=8.82*10) basis points lower and spreads increased by 12 (=1.22*10) basis points more.

These graphs are suggestive that borrowing costs did rise for states that experience poor investment returns in their pension funds. However, the graphs analyze only average returns and spread changes, without controls for other characteristics of the bonds and states that sponsor them. In particular, they do not control for the maturity or duration of the bonds, which may differ across states. Longer duration bonds are more sensitive to changes in interest rates. The figures also do not account for whether the bonds are callable. They analyze investor returns, which are the most easily measured, and not the actual borrowing costs implicit in the prices. The graphs in Figures 2 and 3 also do not control for state level differences such as credit quality, level of debt, level of pension liabilities, and sensitivity of revenues to GDP. These will be important controls in our regression analysis.

Table 3 presents the first set of regression results. The table contains a Panel A in which the main variables of interest are scaled by Gross State Product (GSP), and a Panel B in which they are scaled by total state revenue. Within each panel, we present three columns of regressions. The first column present results for the entire sample without any weights or exclusions, so that a $5,000 tranche of a muni series (the smallest) gets the same weight as a $1 billion tranche (the largest). The second column present results only for bonds with issue size greater than $10M, also unweighted. The third column present results for the full sample but weighted by their issue size. Standard errors are clustered by state in all regressions.

Treating the smallest and largest bonds equally has the disadvantage that these bonds may be less liquid and some of the pricing information less accurate. Bloomberg's data providers estimate the prices of bonds that may not have traded on a given day based on the last traded price and on recent trades in other similar municipal bonds. However, some of the better rated states have smaller bond issues, which is why we present results under these three different treatments of the data. Later in this paper, we also investigate the sensitivity of the result to limiting the sample to bonds that were traded around the start and end dates of the sample.

Using non pre-refunded bonds only (13,160 out of 15,727), Table 3 shows the effect of the value losses on tax-adjusted yield spreads, which we calculate using the methodology explained in Section 3. As explained in Section 2, the tax adjustment reflects a marginal tax rate of 25%. Based on the left column, in which all bonds are treated equally, the effects are only marginally statistically significant. In the middle column, in which we consider only bonds with greater than $10M in offer size, the effect of a loss of 1 percentage point of GSP (Panel A) is around 20 basis points and significant at the 5% level. A loss of 10 percentage points of state revenue (Panel B) is correlated with a spread increase of around 25 basis points. The *Insured* control variable shows that yield spreads on insured bonds increase on average by around 30 basis points more than non-insured bonds over this time period, likely reflecting the problems faced by monoline municipal insurers.

The pre-refunded bonds excluded from Table 3 (approximately 16% of the sample) provide useful within-state control samples to identify the effect of the investment losses on bonds of different values. Given the security offered by pre-refunded bonds, these should not be affected by default considerations (Chalmers (1998)). In Table 4 we therefore use the full sample of 15,727 bonds to estimate an effect on non-prerefunded bonds in states rated AA or below. Of the 39 states in the sample, 22 are AA or below, accounting for 63% of the bonds, and we would not expect an effect of investment losses on yields in the more highly rated states. In all specifications, the triple interaction shows a strong and highly statistically significant effect of investment losses on this group of bonds. For each percentage point of GSP lost, spreads increased on non-prerefunded bonds in AA-or-below states by 18-27 basis points. For each 10 percentage points of revenue lost, spreads increased on non-prerefunded bonds in AA-or-below states by 18-33 basis points. The result is statistically significant at the 1% level in all specifications in Table 4.

One consequence of having small issues in the sample is that they may not trade very often. This is likely the reason that the results are stronger in the columns of Tables 3 and 4 where we exclude the smallest issues or where we weight the results by size. Table 5 examines this trading hypothesis more directly and also examines the robustness of the basic yield spread results in Tables 3 and 4 to the time of trades relative to the measurement dates.

From the Municipal Securities Rulemaking Board (MSRB) we obtained every trade in state bonds during this time period. The first column of Table 5 repeats the statistics from the first columns of Tables 3 and 4. The second column restricts the sample only to bonds that traded within one month of the beginning or end of the 3-month sample period, which reduces the sample by roughly 50%. This first sample restriction increases the magnitude of the results by as much 30% but has mixed effects on statistical significance. The third column restricts the sample only to observations that traded within 10 days of the beginning or end of the sample period, a restriction that further reduces the sample to 5458 observations but which increases the magnitude and statistical significance of the results. The fourth column restricts the sample to a window of 5 trading days, and again raises the magnitude and statistical significance of the results.

The final column includes only bonds that were traded either on September 30th, 2008 or December 31st, 2008. Here the sample is only 5% as large as the full sample, but the coefficients are 2-3 times as large and all the coefficients are significant at the 1% level. An investment loss of 10% of revenue or 1% of GDP is correlated with a 27-35 basis point increases in the tax-adjusted yield spreads. In sum, Table 5 supports the notion that some of the statistical weakness in the full sample is in part due to stale pricing information.

Table 6 further expands the analysis by examining interactions with finer ratings categories and also including controls in columns (2) and (4) for the ratio of state debt to GSP, the ratio of state pension liabilities to GSP, and the historical (1992-2007) sensitivity of revenues to U.S. GDP. These are unweighted, full-sample regressions. Again, a natural hypothesis is that states with worse credit ratings ex ante should display larger responses, and this is indeed what the results show. Among the states that are rated between A and AA-, the effect is 22-23 basis points per percentage point of GSP lost, and 24-25 basis points per 10% of annual state revenue lost. Among states that are rated AA, the effects are one-third to one-half as large, around 8-13 basis points. Among states rated AA+ or AAA (the omitted interaction), the effect is not present. This evidence is consistent with the idea that markets punished states with greater investment losses through higher yields due to concerns about possible defaults.

The fact that the results are robust to credit rating interactions shows that even within these categories, states that had greater losses experienced relatively larger yield spread increases on their traded, non-refunded bonds. The effect is therefore not simply due to a correlation of large investment losses with poor credit ratings, or due to one or two outlying states in the worst rating category.

Figure 4 illustrates the results of Table 6 in graphical form. The figure shows the effects of state investment losses on yield spreads during the period September-December 2008 for non pre-refunded bonds of differing credit quality. The numbers shown are from the triple-difference regression shown in columns (2) and (4) of Table 6, in which the omitted indicator is the indicator for the highest rating category (AA+ to AAA). For states in the highest rating category (AA+ to AAA), the numbers represent the sum of coefficients on [ΔFunds / X] and [Not Pre-Refunded]*[ΔFunds / X], where X = GSP or State Revenue in the left and right groups of bars, respectively. For states in the AA category, the figures are the sum of 4 coefficients: i.) [ΔFunds / X], ii.) [Not Pre-Refunded]*[ΔFunds / X], iii.) [ΔFunds / X]*[AA Rated] and iv.) [Not Pre-Refunded]*[ΔFunds / X]*[AA Rated]. For states in the AA category, the figures are the sum of 4 coefficients: i.) [ΔFunds / X], ii.) [Not Pre-Refunded]*[ΔFunds / X], iii.) [ΔFunds / X]*[A to AA-] and iv.) [Not Pre-Refunded]*[ΔFunds / X]*[A to AA-].

Figure 4 shows that the effect on the yield spread for non prerefunded bonds increases as credit quality decreases. It does not show the full effect found in Table 6, because the triple interaction of [Not Pre-Refunded]*[ΔFunds / X]*[AA Rated] also exploits the differences in spread changes between pre-refunded versus not pre-refunded bonds in the same state. As the investment loss [ΔFunds / X] increases, this difference between the behavior of pre-refunded versus not pre-refunded bonds grows larger for AA rated states than for states in the highest rating category. As a result, the difference in the AA category versus the highest rating category is much stronger in the triple interaction term than is implied by the bars in Figure 4.

Regarding the other controls in Table 6, pension liabilities here are measured under Treasury discount rates as calculated in Novy-Marx and Rauh (2009), which reflects the assumption that market participants were sophisticated enough to view the state disclosures as substantially understated. However, the results are not affected if we use stated liabilities as a control.[14]

In Table 7 we limit the sample to only those 8,089 bonds that are not pre-refunded and rated AA or below, in order to examine whether bonds covered by a monoline insurer were less affected by the investment losses. We might have expected the insurance to provide some protection, but at the same time, the value of the insurance during this period declined substantially. The table illustrates several notable findings. In two of the three specifications (the full-sample unweighted on the left and the full-sample weighted on the right) the existence of insurance does not have a statistically significant protective effect on the increase in yield spreads — though it should be noted that the insured bonds of course had lower yield spreads to begin with. In the regressions on the sample of issues greater than $10 million, the effect of the investment losses on the change in the yield spread is about half as large for insured bonds as it is for uninsured bonds. For example, each percentage point of GSP lost is correlated with a 14.15 basis point increase in the tax adjusted spread if the bond is insured, but a 28.07 (= 14.15+13.92) basis point increase if the bond is uninsured.

[14] We are also using accumulated benefit obligation (ABO) liabilities, i.e. those already legally accrued by workers for service to date, as these are the ones that are more clearly senior to state general obligation bonds. See Novy-Marx and Rauh (2009, 2010) for further discussion.

In untabulated results, we examine whether the yield spread effect is higher for each year of bond duration. At best we find weak evidence of this. For example, if we expand the regression in column (1) of Table 3 to include interactions with duration, the coefficient on [ΔFunds / GSP]*[Rated AA or Below]*[Duration] is small and has a t-statistic of 0.5, while the coefficient on [ΔFunds / GSP]*[Rated AA or Below] is 12.96 with a t-statistic of 2.72. If we weight by size, there is some evidence that among the largest bonds, the spread effect is larger for longer duration bonds, but this effect is driven by the very largest bonds. Similarly, if we replace the insurance interactions in Table 7 (non pre-refunded bonds rated AA or below only) with duration interactions, the coefficient on [dFunds / GSP]*[Duration] is small and has a t-statistic of 0.6, while the coefficient on [dFunds / GSP] is 12.56 with a t-statistic of 2.90. In this setting as well, if we weight by size, there is some evidence that among the largest bonds, the spread effect is larger for longer duration bonds, but again, this effect is driven by the very largest bonds. We conclude that the effect is approximately constant over the yield curve, suggesting a constant upward shift in annual risk-neutral default probabilities (or downward shift in recovery rates) implied by market yields.

5. Conclusions

This paper uses variation across states in investment losses during the last quarter of 2008 to measure the effects of increases in unfunded liabilities on municipal bond yields at the state level. Our results imply that U.S. state municipal bond yields will likely increase if unfunded state liabilities continue to grow, making new state debt more expensive to finance.

It is instructive to compare the states' fiscal position to that of the U.S. federal government. Across all 50 states, total on-balance-sheet state government debt amounts to approximately $0.94 trillion, while unfunded pension liabilities are $3.2 trillion when measured at Treasury rates. Given total state revenue of around $750 trillion, the ratio of unfunded liabilities to revenue for the 50 states combined is about 2.8, excluding public medical programs. This fiscal position appears stronger than that of the U.S. government, which collects about $2.5 trillion in annual revenue, compared to $9 trillion in debt, an approximately $10.5 trillion gap in Social Security (Geanakoplos and Zeldes (2009)), and an unfunded liability for civil service employees of around $0.6 trillion (Office of Personnel Management (2005)). In total, the U.S. government's unfunded liabilities excluding public medical programs are therefore around 8 times its annual revenue.

The behavior of municipal yield spreads therefore highlights the fact that fundamental differences between state governments and the U.S. federal government — or differences between the markets for their debt — generate important differences in borrowing rates. The U.S. dollar plays a unique role as a reserve currency at the world's central banks, and U.S. Treasury debt enjoys superior trading liquidity as well as a perception by market participants that it is risk-free (Krishnamurthy and Vissing-Jorgensen (2008)). The nature of the default events and likely extent of recovery are also very different, with the federal government retaining the capacity to erode the value of its debt through inflation. Understanding the effects of state and federal fiscal decisions on bond markets is an important avenue for future research.

Appendix: The Black Value of a Swaption

This appendix shows the computation of the Black value of a swaption, expiring in *t* and written on a swap with tenor *T* making semi-annual payments at the rate *c.* Define F as the future swap rate, adjusted for the call's strike:

$$F = \frac{2\left((strike/face)\times B_t - B_{t+T}\right)}{\sum_{i=1}^{2T} B_{t+i/2}},$$

where B_τ in the price of a zero-coupon bond of the same quality as the bond underlying the swap maturing at τ. The Black value of the swaption is then

$$A \times \left(\frac{c}{2}\, N(-d_2) - \frac{F}{2}\, N(-d_1)\right),$$

where *A* is the sum of the state prices for all the swap's payment dates, *N* is the cumulative normal distribution σ is the implied volatility of a swap maturing it *t* with tenor *T*, $d_1 = \frac{log(F/c)+\sigma^2 t/2}{\sigma\sqrt{t}}$, and $d_2 = d_1 - \sigma\sqrt{t}$.

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Figure 1: General Obligation Municipal Bond Yield Spreads, 9/30/2008 - 12/31/2008

The figures show yield spreads of par yield curves over Treasuries on 9/30/2008, 12/31/2008, and the change over that time period. Data are from the Bloomberg yield curve function (F82 for the Treasuries, and M49, M45, M163, and M159 for the AAA, AA+, A+, and A- general obligation municipals respectively).

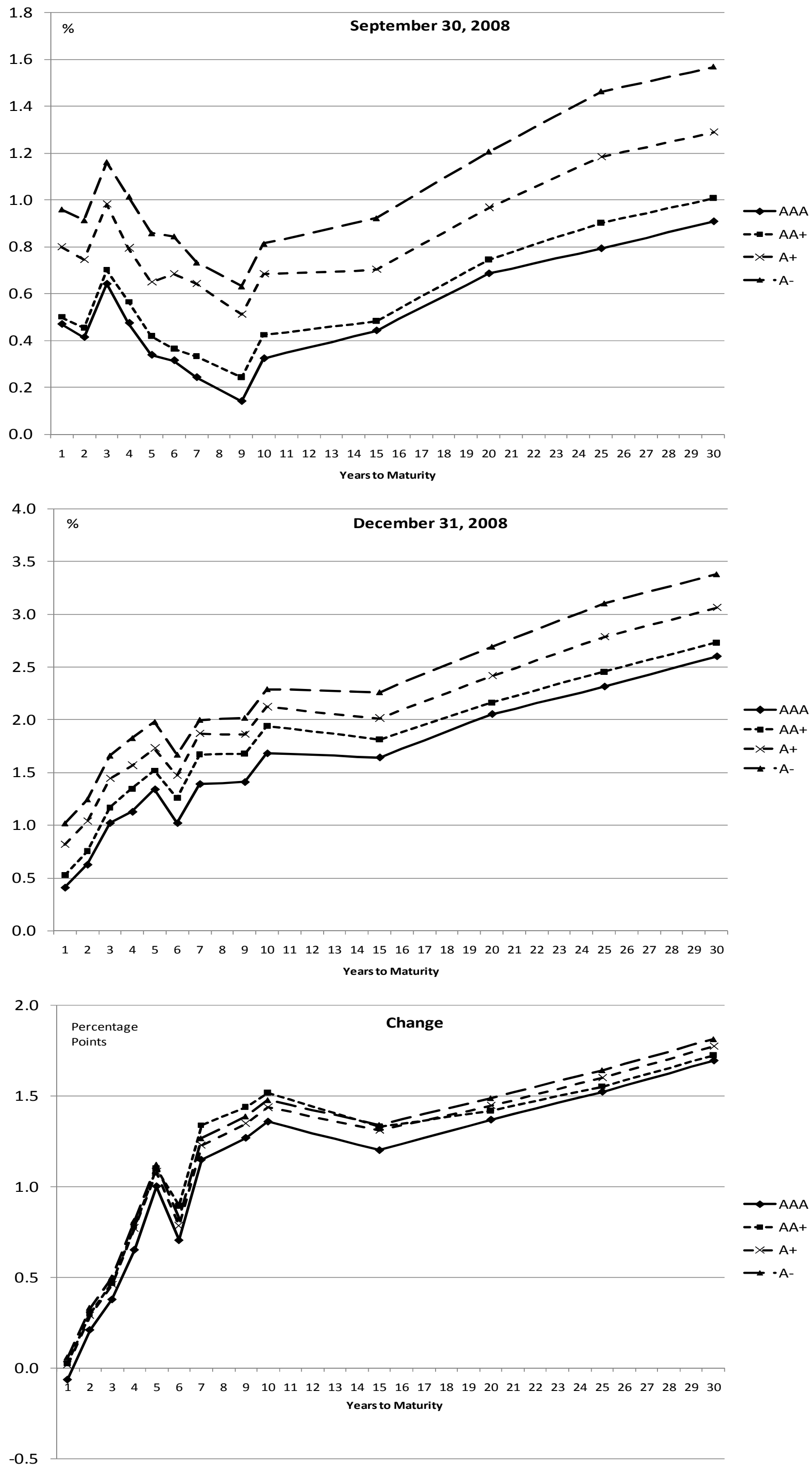

Figure 2: Average General Obligation Municipal Bond Returns and State Pension Funds, September-December 2008

These figures show relations between value-weighted average returns on state bonds between September 30, 2008 and December 31, 2008 (the vertical axis in all four graphs) and state pension fund variables. Of the 15,727 bonds in the universe, only the 7,947 bonds with duration greater than 5 years that have not been pre-refunded are included. The graphs differ in the horizontal axis, showing: i.) the share of pension fund assets in equity and real estate; ii.) the estimated pension fund percentage loss in 2008Q4,; iii.) the level of state pension assets as a share of state government revenue; and iv.) the estimated value lost in the pension fund as a percentage of state government revenue.

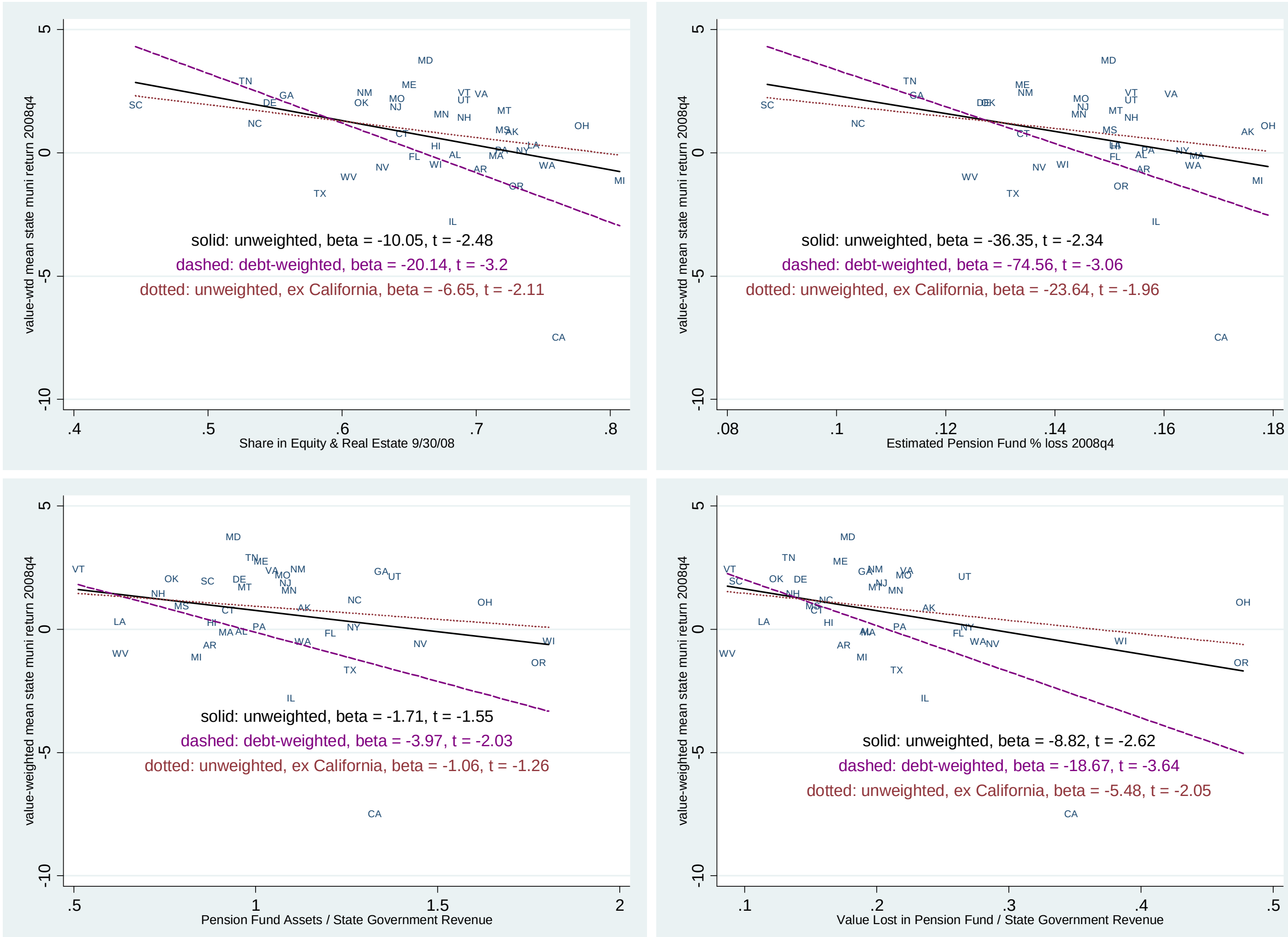

Figure 3: Spread Changes and State Pension Funds, September-December 2008

These figures show relations between changes in tax-adjusted spreads on state bonds between September 30, 2008 and December 31, 2008 (the vertical axis in all four graphs) and state pension fund variables. Of the 15,727 bonds in the universe, the 7,947 bonds with duration greater than 5 years that have not been pre-refunded are included. The graphs differ in the horizontal axis, showing: i.) the share of pension fund assets in equity and real estate; ii.) the estimated pension fund percentage loss in 2008Q4,; iii.) the level of state pension assets as a share of state government revenue; and iv.) the estimated value lost in the pension fund as a percentage of state government revenue.

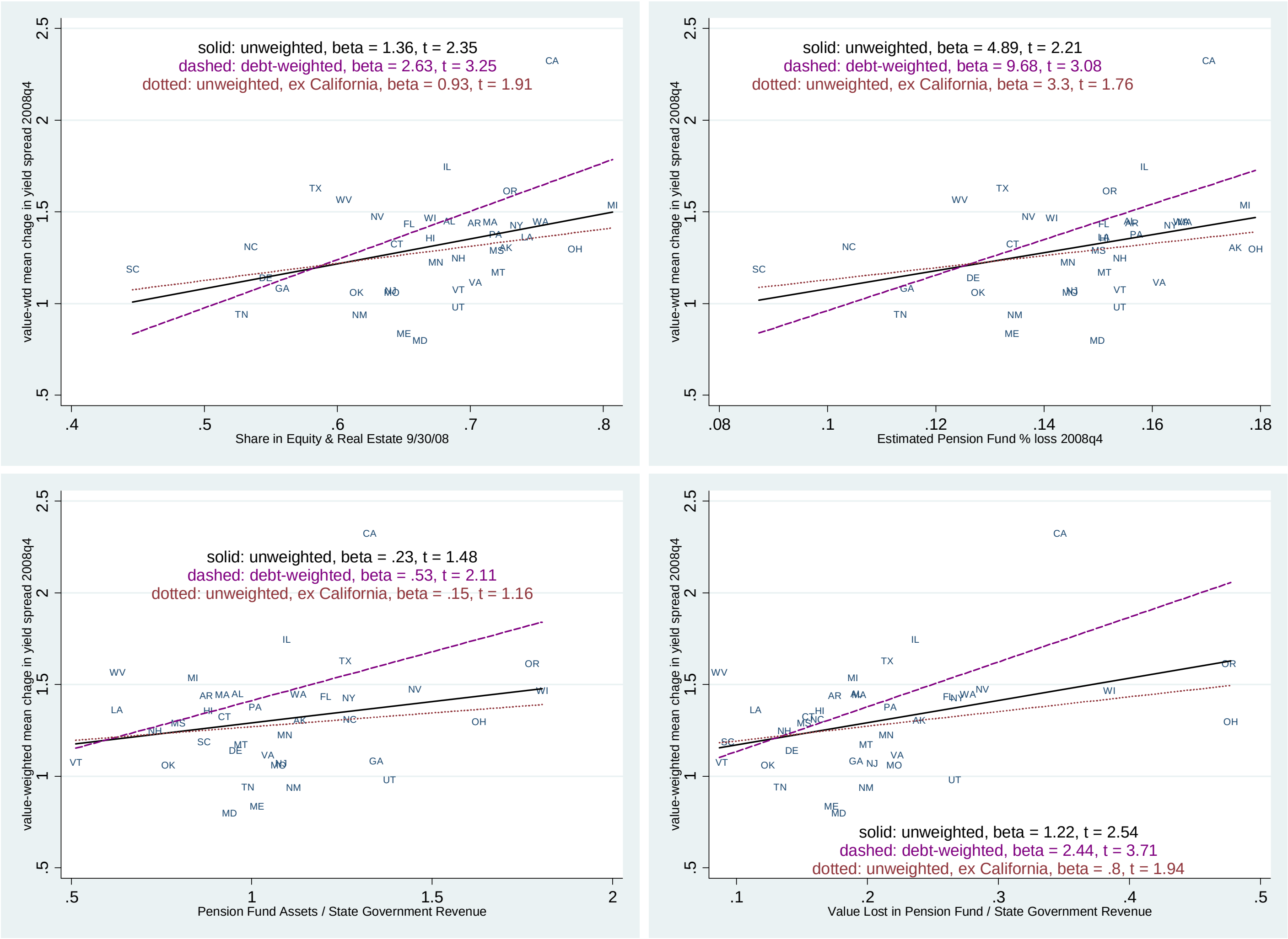

Figure 4: Effects of Investment Losses on Yield Spreads for Non Pre-Refunded Bonds, September-December 2008

The figure shows the effects of state investment losses on yield spreads during the period September-December 2008 for non pre-refunded bonds of differing credit quality. The numbers shown are from the triple-difference regression shown in columns (2) and (4) of Table 6, in which the omitted indicator is the indicator for the highest rating category (AA+ to AAA). For states in the highest rating category (AA+ to AAA), the numbers represent the sum of coefficients on [ΔFunds / X] and [Not Pre-Refunded]*[ΔFunds / X], where X = GSP or State Revenue in the left and right groups of bars, respectively. For states in the AA category, the figures are the sum of 4 coefficients: i.) [ΔFunds / X], ii.) [Not Pre-Refunded]*[ΔFunds / X], iii.) [ΔFunds / X]*[AA Rated] and iv.) [Not Pre-Refunded]*[ΔFunds / X]*[AA Rated]. For states in the AA category, the figures are the sum of 4 coefficients: i.) [ΔFunds / X], ii.) [Not Pre-Refunded]*[ΔFunds / X], iii.) [ΔFunds / X]*[A to AA-] and iv.) [Not Pre-Refunded]*[ΔFunds / X]*[A to AA-].

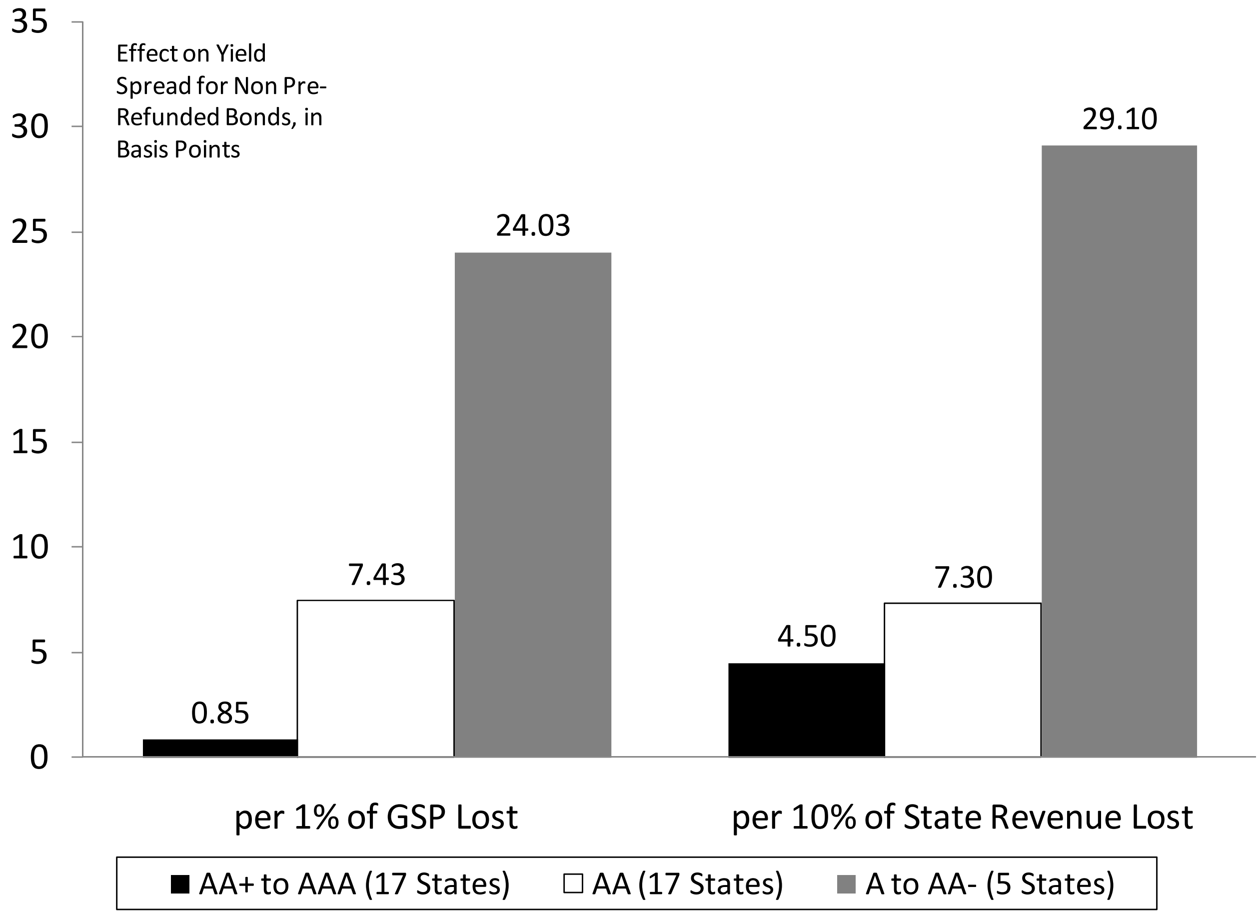

Table 1: Municipal Bond Summary Statistics (N = 15,727)

This table shows summary statistics on the 15,727 municipal bonds used in the study. The sample consists of the universe of state sponsored, general obligation municipal bonds in the S&P CUSIP Master File that were outstanding during the sample period of September 30, 2008 through December 31, 2008.

Characteristics

	mean	median	stdev	p25	p75
Issue Size ($ millions)	44.9	6.7	226.0	1.4	16.8
Issue Year	2003	2003	4	2001	2006
Maturity Year	2017	2015	5	2012	2020
Coupon	4.631	5.000	1.126	4.250	5.125
Insured Indicator	0.322	0.000	0.467	0.000	1.000
Pre-Refunded	0.163	0.000	0.370	0.000	0.000
Callable	0.607	1.000	0.488	0.000	1.000

Yields, Spreads, and Returns

	mean	median	stdev	p25	p75
Simple Return (%)	0.942	1.345	2.792	0.209	2.538
Duration	5.789	5.142	3.581	2.695	8.458
Convexity (÷100)	0.552	0.286	0.652	0.075	0.830
Yield 9/30/2008 (%)	3.719	3.685	0.877	2.982	4.449
Yield 12/31/2008 (%)	3.258	3.219	1.327	2.255	4.306
Yield Spread 9/30/2008	0.638	0.550	0.415	0.426	0.724
Yield Spread 12/31/2008	1.651	1.453	0.722	1.193	2.100
Tax-Adjusted Yield Spread 9/30/2008	1.877	1.691	0.579	1.464	2.215
Tax-Adjusted Yield Spread 12/31/2008	2.737	2.539	1.129	1.989	3.521
Change in Tax-Adjusted Yield Spread	0.860	0.882	0.725	0.341	1.350
- Not Pre-Refunded Only (N=13,160)	1.050	1.043	0.610	0.592	1.420
- Pre-Refunded Only (N=2,567)	-0.112	-0.229	0.431	-0.379	0.096

Table 2: State-Level Fiscal and Pension Summary Statistics (N=39)

Summary statistics are presented for the 39 states that sponsored pension plans for employees and had traded general obligation municipal bonds in 2008. State fiscal measures are from the Bureau of Economic Analysis and the U.S. Census Bureau. Pension fund assets and asset allocation as of September 2008 are from *Pensions and Investments*. Pension fund liabilities are from states' Comprehensive Annual Financial Reports (see Novy-Marx and Rauh (2009, 2010) for further details). ΔFunds is calculated by using return indices for the pension fund asset classes from September 2008 through December 2008, which were collected from the Kenneth R. French Data Library (the Fama-French factors), Barra MSCI, and Lehman Brothers / Barclays. Total Revenue is the sum of taxes, inter-governmental revenue, and charges; it excludes revenue the states impute as arising from their pension funds.

State Fiscal Measures for 2007	mean	median	stdev	p25	p75
Gross State Product (GSP), $ billion	315.2	216.3	361.0	82.4	389.7
Tax Revenue, $ billion	17.4	10.9	20.5	5.6	21.6
Total Revenue, $ billion	34.1	23.1	37.3	11.7	40.6
State Debt, $ billion	22.0	11.4	26.1	5.9	23.9
- as share of GSP	0.082	0.071	0.040	0.054	0.099
- as share of Total Revenue	0.667	0.632	0.323	0.479	0.801
S&P Rating AAA	0.231	0.000	0.427	0.000	0.000
S&P Rating AA+	0.205	0.000	0.409	0.000	0.000
S&P Rating AA	0.436	0.000	0.502	0.000	1.000
S&P Rating A to AA–	0.128	0.000	0.339	0.000	0.000

Pension Fund Assets and Liabilities	mean	median	stdev	p25	p75
Number of Pension Plans	2.4	2.0	1.4	1.0	3.0
Pension Fund Assets, September 2008, $ billion	54.6	29.2	72.9	16.5	63.3
Liabilities: Stated Rates and Methods, $ billion	69.7	42.8	86.8	20.6	72.5
Liabilities: Stated Rates, ABO ($ billion)	66.2	41.5	81.9	19.6	69.7
- as share of GSP	0.227	0.212	0.070	0.177	0.265
- as share of Total Revenue	1.894	1.828	0.588	1.543	2.083
Liabilities: Treasury Rates, ABO ($ billion)	142.0	95.8	170.4	46.2	153.9
- as share of GSP	0.358	0.332	0.111	0.269	0.415
- as share of Total Revenue	2.985	2.823	0.953	2.376	3.439

Pension Fund Asset Allocation (9/30/2008)	mean	median	stdev	p25	p75
Domestic Stock	0.349	0.351	0.072	0.309	0.410
Domestic Fixed Income	0.243	0.243	0.079	0.202	0.276
International Stock	0.184	0.180	0.039	0.164	0.208
International Fixed Income	0.034	0.007	0.068	0.000	0.035
Cash and Equivalents	0.015	0.010	0.016	0.003	0.021
Private Equity	0.071	0.060	0.057	0.031	0.093
Real Estate Equity	0.059	0.062	0.040	0.033	0.090
Mortgages	0.005	0.000	0.008	0.000	0.009
Other	0.039	0.020	0.043	0.003	0.068
Estimated Return (9/30/2008 - 12/31/2008)	-0.146	-0.151	0.020	-0.157	-0.134

Pension Fund Value Loss (9/30 to 12/31)	mean	median	stdev	p25	p75
ΔFunds ($ billions)	8.4	4.1	12.3	2.3	9.1
- as share of GSP	0.025	0.024	0.011	0.017	0.029
- as share of Total Revenue	0.211	0.194	0.090	0.158	0.238

Table 3: Change in Yield Spread and Value Lost in Pension Funds, Non Pre-Refunded Bonds

This table shows regressions of municipal bond yield spreads on changes in the value of state pension fund assets for non pre-refunded bonds only. The municipal yields underlying the bond spreads were adjusted for taxes assuming a marginal tax rate of 25%. Scaling is by Gross State Product (GSP) in Panel A, and by total state revenue (excluding insurance trust revenues) in Panel B.

	Dependent Variable: Change in Tax-Adjusted Yield Spread		
Panel A: GSP Scaling	(1)	(2)	(3)
[Rated AA or Below] * [ΔFunds / GSP]	10.44	19.54	20.72
	(5.37)*	(9.36)**	(3.65)***
ΔFunds / GSP	-0.14	0.82	1.26
	(1.45)	(2.56)	(1.66)
Rated AA or Below	-0.08	-0.32	-0.37
	(0.12)	(0.19)	(0.09)***
Insured	0.29	0.30	0.34
	(0.04)***	(0.07)***	(0.05)***
Duration	0.15	0.15	0.15
	(0.01)***	(0.01)***	(0.01)***
Convexity ÷ 100	-0.12	-0.04	0.05
	(0.10)	(0.08)	(0.04)
Constant	-0.08	-0.17	-0.26
	(0.06)	(0.09)*	(0.07)***
R-squared	0.705	0.785	0.839
	Dependent Variable: Change in Tax-Adjusted Yield Spread		
Panel B: Revenue Scaling	(1)	(2)	(3)
[Rated AA or Below] * [ΔFunds/Revenue]	0.98	2.52	2.47
	(0.67)	(1.00)**	(0.35)***
[ΔFunds/Revenue]	0.06	0.08	0.11
	(0.19)	(0.29)	(0.17)
Rated AA or Below	-0.03	-0.43	-0.43
	(0.14)	(0.20)**	(0.09)***
Insured	0.29	0.32	0.34
	(0.04)***	(0.07)***	(0.05)***
Duration	0.15	0.15	0.16
	(0.01)***	(0.01)***	(0.01)***
Convexity ÷ 100	-0.13	-0.07	0.02
	(0.09)	(0.08)	(0.05)
Constant	-0.10	-0.18	-0.26
	(0.06)	(0.09)*	(0.07)***
R-squared	0.702	0.795	0.842
Sample	Not Pre-Refunded	Not Pre-Refunded, Only Issues >$10M	Not Pre-Refunded
Weights	None	None	Issue Size
Observations	13160	4972	13160

Robust standard errors in parentheses, clustered by state
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Yield Spread Changes by State Investment Loss, Credit Rating and Pre-Refunded Status

This table shows regressions of municipal bond yield spreads on changes in the value of state pension fund assets, interacted with credit rating categories and indicators for whether the bond is pre-refunded. 22 of the 39 states in the sample, accounting for 63% of the bonds, are rated AA or below. The municipal yields underlying the bond spreads were adjusted for taxes assuming a marginal tax rate of 25%. Scaling is by Gross State Product (GSP) in Panel A, and by state revenue in Panel B. Credit ratings are from S&P.

	Dependent Variable: Change in Tax-Adjusted Yield Spread					
	Panel A: Scaling by X = GSP			Panel B: Scaling by X = Revenue		
	(1)	(2)	(3)	(4)	(5)	(6)
Triple Interaction						
[Not Pre-Refunded]*[ΔFunds / X]*[AA or Below]	18.510	27.370	20.390	1.810	3.330	2.230
	(6.52)***	(9.30)***	(4.14)***	(0.77)**	(0.94)***	(0.48)***
Double Interaction						
[Not Pre-Refunded]*[ΔFunds / X]	-3.900	-3.130	0.530	-0.370	-0.490	0.090
	(2.13)*	(3.740)	(3.270)	(0.310)	(0.390)	(0.440)
[Not Pre-Refunded]*[AA or Below]	-0.210	-0.400	-0.240	-0.140	-0.490	-0.250
	(0.160)	(0.23)*	(0.13)*	(0.180)	(0.22)**	(0.14)*
[ΔFunds / X]*[AA or Below]	-8.250	-15.930	-8.380	-0.660	-1.580	-0.390
	(3.48)**	(5.31)***	(4.24)*	-0.45	(0.65)**	-0.71
Controls						
[ΔFunds / X]	7.580	14.250	8.230	0.490	1.320	0.490
	(3.78)*	(4.70)***	(4.28)*	(0.420)	(0.60)**	(0.650)
[Rated AA or Below]	0.170	0.390	0.170	0.100	0.340	0.030
	(0.130)	(0.18)**	(0.160)	(0.150)	(0.220)	(0.230)
Pre-Refunded (= 1-Not Pre-Refunded)	-0.470	-0.370	-0.270	-0.460	-0.410	-0.260
	(0.08)***	(0.14)**	(0.12)**	(0.09)***	(0.14)***	(0.13)*
Insured	0.260	0.270	0.300	0.260	0.280	0.300
	(0.03)***	(0.05)***	(0.04)***	(0.03)***	(0.05)***	(0.04)***
Duration	0.170	0.180	0.190	0.170	0.180	0.190
	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***
Convexity	-0.210	-0.190	-0.090	-0.210	-0.190	-0.100
	(0.08)**	(0.06)***	(0.03)***	(0.08)**	(0.07)***	(0.03)***
State Debt / X	-1.130	-2.780	-2.120	-0.800	-1.870	-1.210
	(0.690)	(0.93)***	(0.67)***	(0.830)	(1.180)	(0.960)
Pension Liabilities / X	-0.500	-1.010	-0.660	-0.170	-0.680	-0.360
	(0.350)	(0.42)**	(0.38)*	(0.330)	(0.450)	(0.450)
Sensitivity of Revenue to U.S. GDP	-2.150	8.160	7.450	-3.330	5.110	4.280
	(3.560)	(3.73)**	(3.12)**	(4.350)	(4.700)	(3.950)
Constant	0.030	-0.090	-0.280	-0.030	-0.140	-0.330
	(0.10)	(0.10)	(0.11)**	(0.10)	(0.12)	(0.12)***
Sample	All	>$10M	All	All	>$10M	All
Weights	None	None	Issue Size	None	None	Issue Size
Observations	15727	6249	15727	15727	6249	15727
R-squared	0.810	0.866	0.877	0.806	0.864	0.876

Robust standard errors in parentheses, clustered by state

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Robustness of Basic Yield Spread Change Results to Time of Trades

This table revisits the key coefficients in Tables 3 and 4 using subsamples based on the time window in which the bond was last traded. The first column of the top panel repeats the results from Table 3, Column 1. The first column of the bottom panel repeats the results from Table 4, Column 1. The successive columns then narrow the band of trading days. For example, the second column excludes bonds that did not trade within one month of the beginning or end of the sample period. The third column excludes bonds that did not trade within 10 days of the beginning or end of the sample period, and so on.

	All	+/- 1 mth	+/- 10 trading days	+/- 5 trading days	on last trading day
Table 3, Column 1					
[Rated AA or Below * dFunds / GSP]	10.44	13.43	16.00	17.70	27.33
	(5.37)*	(8.13)	(8.78)*	(9.34)*	(8.97)***
[Rated AA or Below * dFunds / Revenue]	0.98	1.64	1.98	2.16	3.25
	(0.67)	(0.96)*	(1.01)*	(1.05)**	(0.94)***
Table 4, Column 1					
[Not PreRef]*[ΔFunds / GSP]*[AA or Below]	18.51	19.19	22.62	24.94	30.78
	(6.52)***	(9.78)*	(10.16)**	(10.46)**	(7.64)***
[Not PreRef]*[ΔFunds / Rev]*[AA or Below]	1.81	2.25	2.70	2.98	3.47
	(0.77)**	(1.07)**	(1.09)**	(1.11)**	(0.80)***
Observations	15727	7707	5458	3751	813
Not Prerefunded Observations	13160	6149	4308	2977	664

Robust standard errors in parentheses, clustered by state

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6: Triple Difference Specification, Finer Ratings Categories

This table shows unweighted, full-sample regressions of municipal bond yield spreads on changes in the value of state pension fund assets, interacted with credit rating categories and indicators for whether the bond is pre-refunded. The municipal yields underlying the bond spreads were adjusted for taxes assuming a marginal tax rate of 25%. Scaling is by Gross State Product (GSP) in columns (1)-(2), and by state revenue in (3)-(4).

	Dependent Variable: Change in Tax-Adjusted Yield Spread			
	Scaling by X = GSP		Scaling by X = Revenue	
	(1)	(2)	(3)	(4)
Triple Interactions				
[Not Pre-Refunded]*[ΔFunds / X]*[A to AA-]	22.15	23.26	2.40	2.53
	(7.61)***	(7.49)***	(0.77)***	(0.76)***
[Not Pre-Refunded]*[ΔFunds / X]*[AA Rated]	10.15	12.82	0.83	1.06
	(3.23)***	(3.37)***	(0.49)*	(0.42)**
Double Interactions				
[ΔFunds / X]*[A to AA-]	0.08	1.55	-0.11	-0.05
	(3.14)	(4.55)	(0.31)	(0.35)
[ΔFunds / X]*[AA Rated]	-4.86	-6.24	-0.61	-0.78
	(1.57)***	(1.75)***	(0.19)***	(0.24)***
[Not Pre-Refunded]*[A to AA-]	-0.04	-0.08	-0.04	-0.07
	(0.27)	(0.27)	(0.26)	(0.26)
[Not Pre-Refunded]*[AA Rated]	-0.03	-0.13	0.04	-0.04
	(0.11)	(0.11)	(0.15)	(0.13)
[Not Pre-Refunded]*[ΔFunds / X]	-2.33	-2.98	-0.19	-0.29
	(2.67)	(2.46)	(0.35)	(0.31)
Controls				
[ΔFunds / X]	2.36	3.83	0.30	0.74
	(1.35)*	(2.74)	(0.17)*	(0.29)**
A to AA-	-0.15	-0.18	-0.11	-0.14
	(0.12)	(0.16)	(0.11)	(0.12)
AA Rated	0.02	0.10	0.03	0.13
	(0.07)	(0.07)	(0.07)	(0.09)
Pre-Refunded (= 1-Not Pre-Refunded)	-0.42	-0.44	-0.40	-0.43
	(0.09)***	(0.09)***	(0.10)***	(0.09)***
Insured	0.23	0.23	0.23	0.24
	(0.04)***	(0.03)***	(0.03)***	(0.04)***
Duration	0.17	0.17	0.17	0.17
	(0.01)***	(0.01)***	(0.01)***	(0.01)***
Convexity	-0.24	-0.25	-0.25	-0.26
	(0.06)***	(0.06)***	(0.06)***	(0.06)***
Ratio of Debt to GSP		-0.56		-0.09
		(0.39)		(0.06)
Ratio of Pension Liabilities to GSP		-0.15		-0.05
		(0.24)		(0.02)*
Sensitivity of Revenue to U.S. GDP		-3.02		-1.68
		(2.70)		(2.27)
Constant	-0.14	-0.05	-0.16	-0.04
	(0.06)**	(0.07)	(0.06)***	(0.08)
Observations	15727	15727	15727	15727
R-squared	0.833	0.836	0.833	0.837

Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7: Insurance Interactions for Non Pre-Refunded Bonds Rated AA or Below

This table shows regressions of municipal bond yield spreads on changes in the value of state pension fund assets, with interactions for whether the bond was covered by a monoline insurer. The municipal yields underlying the bond spreads were adjusted for taxes assuming a marginal tax rate of 25%. Scaling is by Gross State Product (GSP) in Panel A, and by state revenue in Panel B.

Panel A: GSP Scaling	*Dependent Variable: Change in Tax-Adjusted Yield Spread*		
ΔFunds / GSP	13.14	14.15	26.50
	(7.00)*	(8.16)*	(4.35)***
[Not Insured] * [ΔFunds / GSP]	-4.30	13.92	-1.63
	(6.63)	(4.18)***	(6.54)
Insured	0.12	0.64	0.26
	(0.17)	(0.11)***	(0.18)
Duration	0.14	0.15	0.18
	(0.02)***	(0.02)***	(0.01)***
Convexity	-0.07	-0.04	-0.05
	(0.12)	(0.10)	(0.10)
Constant	-0.08	-0.69	-0.78
	(0.13)	(0.19)***	(0.17)***
R-squared	0.636	0.755	0.815
Panel B: Revenue Scaling	*Dependent Variable: Change in Tax-Adjusted Yield Spread*		
[ΔFunds / Revenue]	1.40	1.95	3.03
	(0.79)*	(0.86)**	(0.48)***
[Not Insured] * [ΔFunds/Revenue]	-0.54	1.48	-0.07
	(0.67)	(0.52)**	(0.78)
Insured	0.11	0.65	0.30
	(0.15)	(0.14)***	(0.20)
Duration	0.14	0.15	0.18
	(0.02)***	(0.02)***	(0.02)***
Convexity	-0.08	-0.09	-0.09
	(0.11)	(0.11)	(0.13)
Constant	-0.03	-0.80	-0.87
	(0.15)	(0.22)***	(0.22)***
R-squared	0.631	0.768	0.812
Sample	AA or Below	AA or Below	AA or Below
	Not Prerefunded	Not Prerefunded	Not Prerefunded
		Issues >$10M	
Weights	None	None	Issue Size
Observations	8089	3287	8089

Robust standard errors in parentheses, clustered by state

* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix Table 1: Asset Allocation and Asset Class Returns

The top panel shows asset allocation for 71 investment funds across 116 pension plans for 50 states as reported by *Pensions and Investments*, as of September 2008. As a proxy for the returns to domestic stock, international stock and real estate we use the returns to Barra/MSCI Investible Indices (USA, World ex-USA and US REIT, respectively). For domestic fixed income, international fixed income, mortgages and the "other" category we use Barclays Capital Indices (US Government/Credit, Global Aggregate Ex USA, US MBS and Asset-Weighted Hedge Fund, respectively). The returns to cash and equivalents are from Ken French's website (one month risk-free rate). For the return to private equity we use the mid-point of the range estimated by Steven N. Kaplan (private conversation).

	Asset-Weighted Average Asset Allocation								
	Domestic Stock	International Stock	Domestic Fixed Income	International Fixed Income	Cash and Equivalents	Private Equity	Real Estate Equity	Mortgages	Other
Pensions & Investments, September 2008	35.1%	17.8%	23.7%	2.2%	1.5%	8.0%	7.3%	0.9%	3.4%

	Returns								
	Domestic Stock	International Stock	Domestic Fixed Income	International Fixed Income	Cash and Equivalents	Private Equity	Real Estate Equity	Mortgages	Other
Returns Used to Calculate Totals									
September 2008 to December 2008	-22.8%	-21.5%	2.7%	5.7%	0.2%	-12.5%	-39.1%	-15.0%	-7.4%