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U.S. municipal yields and unfunded state pension liabilities

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Zina Lekniūtė,† Roel Beetsma‡and Eduard Ponds§

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Abstract

We present empirical evidence that municipal bond yields are increasing in the pension debt towards U.S. state civil servants. However, positive yield effects of both pension and explicit debt are found only for the period since the start of the crisis, suggesting that the crisis triggered awareness of budgetary sustainability. The marginal yield effect of higher pension debt is smaller than that of higher explicit debt, but still economically meaningful. The effect of higher pension debt seems stronger when using market values of pension assets than actuarial values, suggesting that investors pay more attention to market values.

Keywords: civil servants pension funds, underfunding, explicit debt, implicit debt, municipal yields, unfunded pension liabilities, market values, actuarial values.

JEL Codes: G12, H74, H75, H55.

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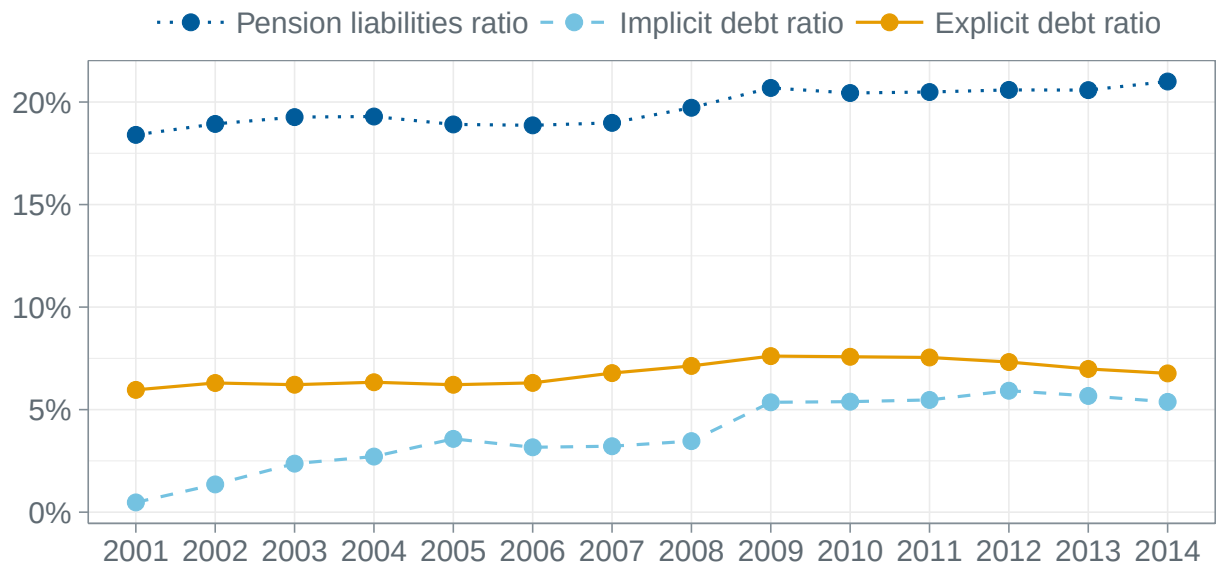
1 Introduction

Both theory and empirical evidence (e.g., Ardagna et al., 2007) suggest that interest rates rise with public indebtedness. However, while the effect of the explicit public debt on its yield has received quite some attention in the literature,[1] how the implicit obligations of governments affect public debt yields has largely been overlooked. This is in particular the case for the unfunded pension liabilities of the U.S. states towards their civil servants, even though these unfunded liabilities tend to be of a magnitude comparable to the size of the explicit public debt (see Figure 1), and their legal protection is high (Munnell et al., 2014). The unfunded state pension liabilities arise from the defined-benefit character of the state civil servants' pensions. Over their working life civil servants accumulate entitlements to future pension benefits. However, the value of these entitlements tends to exceed the accumulated pension capital, thereby resulting in unfunded pension liabilities. Because of their high degree of legal protection, high unfunded pension liabilities may threaten the full repayment of the state's explicit debt as well as the provision of public goods.

Figure 1: Median state debt and (unfunded) pension liabilities



Note: The figure shows the development over time of three debt measures expressed as a percentage of gross state product: actuarial pension liabilities aggregated over the state pension funds (the "pension liabilities ratio"), unfunded actuarial liabilities, calculated as the difference between actuarial liabilities and actuarial assets, aggregated over the state pension funds (the "implicit debt ratio") and the explicit state debt (the "explicit debt ratio"). Actuarial liabilities are the liabilities calculated on the basis of the fund's actuarial assumptions. Reported actuarial assets smooth out fluctuations in the market values of the assets. The dots represent the median values over the states in each year. Data source: Public Plans Database of the Center for Retirement Research at Boston College (2015).

In this paper we explore how the funding situation of the state civil servants' pension funds affects municipal debt yields, while controlling for other variables that might be expected to

[1] Henceforth, we will refer to state debt issued as such as "explicit debt", while we will refer to the unfunded pension liabilities, i.e. the difference between pension liabilities and pension assets, as "implicit debt".

affect these yields, in particular the level of the explicit state debt itself. Our sample is dictated by the availability of the relevant information on the state pension funds and consists of a panel of all U.S. states over the period 2001 - 2014.

In line with what cross-country empirical analyses usually find, we confirm the positive link between the state explicit debt ratio and the municipal debt yield.[2] More importantly, controlling for the state explicit debt ratio we find that an increase in the ratio of unfunded pension liabilities, i.e. the implicit debt ratio, or a reduction in the pension funding ratio exerts a significant positive effect on the state's municipal yield.[3] In fact, we find that the marginal yield effect of an increase in the implicit debt ratio is smaller than, though still of an order of magnitude roughly comparable to, that of an increase in the explicit debt ratio. Moreover, these yield effects are mainly concentrated in the period since the start of the recent economic and financial crisis. They likely indicate higher perceived default rates, although they may also capture other factors, such as changes in market liquidity. Unfortunately, markets for credit default swaps do not exist on a systematic and comparable basis for U.S. state debt,[4] so that we are unable to quantify the factors driving the yield effects of higher implicit and explicit debt.

We use a number of variations on our baseline regression to confirm the robustness of our findings. However, we find that if we measure the pension funds' financial health using actuarial instead of market values, the results weaken somewhat. This finding is likely due to the long period over which actuarial asset values smooth changes in market values, so that actuarial asset values may not provide a very accurate picture of the true value of the fund's investment portfolio. Hence, our results suggest that investors in municipal debt see through the potentially inaccurate picture created by the actuarial assessment of the pension funds' financial health, and base their assessment of the state's financial sustainability on a market-based evaluation of the funds' financial situation.

Our findings are of potential importance, because recent years have witnessed a steady across-the-board increase in unfunded state pension liabilities. Because there is no clear seniority ranking between the explicit and implicit debt - witness the Detroit default case during which parts of both the explicit and implicit city debt were written off - an uninterrupted rise in the state pension debt may eventually cause a crisis in the market for the explicit debt, thereby potentially causing states to be shut off from new credit and triggering broader financial turmoil.

The remainder of this paper is organized as follows. Section 2 discusses the relationship of our analysis with the literature. Section 3 presents a descriptive analysis of the dataset, while Section 4 turns to the empirical results. Finally, Section 5 concludes the main body of the paper.

[2]Unless explicitly stated otherwise, a "ratio" stands for the share of the gross domestic product or the gross state product, whichever is relevant.

[3]The funding ratio is the ratio of a pension fund's assets over its liabilities.

[4]This information was directly provided to us by Bloomberg.

2 Relationship with the literature

This paper connects to several strands in the literature. First, it expands to the U.S. state level the empirical analysis of the relationship between a government's financial health, as measured by the explicit public debt or the public deficit, and the yield on its debt. For example, using a panel of sixteen OECD countries over a number of decades, Ardagna et al. (2007) estimate a ten basis points increase in the long-term interest rate for each percentage point increase of the primary deficit ratio. Beetsma et al. (2016) confirm their findings. In a panel of thirty-one advanced and emerging market economies over the period 1980 - 2008 and controlling for a wide range of country-specific factors, Baldacci and Kumar (2010) establish that the positive link between public deficits or public debt and long-term interest rates depends on institutional and other structural factors. Similarly, using a panel of both advanced and emerging market economies, Aisen and Hauner (2013) identify circumstances under which budget deficits affect interest rates positively. Distinguishing between the long-run and the short-run determinants of sovereign borrowing costs, for a sample of twenty-two advanced economies over the period 1980-2010 Poghosyan (2014) finds that a one-percentage point increase in the debt ratio pushes up government bond yields by two basis points in the long-run. However, the literature features less empirical work on the analogous relationship between public financial health at the state level and municipal yields. An early exception is Hastie (1972). Our analysis provides independent supporting evidence for a positive relationship between the explicit state debt and municipal yields, although the focus of our analysis will be on the relationship between the implicit state debt and municipal yields.

Second, our paper connects to the literature addressing budgetary transparency. Alt et al. (2006) explore the determinants of fiscal transparency at the U.S. state level. Reck and Wilson (2006) investigate how information transparency impacts the pricing of municipal bonds. They establish that bond prices incorporate relevant information when this information becomes available. However, they find no evidence that prices react to disclosures required by the Securities and Exchange Commission. Further, although transparency about the implicit pension debt seems to rather low in spite of the financial burden that pension arrangements impose on the government (Ponds et al. (2011)), Bohn and Inman (1996) find no evidence that tighter budgetary restrictions encourage states to push deficits into implicit debt so as to conceal a state's true financial situation.

Third, our paper relates to analyses of the financial health, and its consequences, of the U.S. state pension sector. Novy-Marx and Rauh (2011) calculate state pension sector liabilities in a variety of ways. Based on current salary and service, they obtain figures ranging from 3 to 4.5 trillion dollars, significantly more than the value of the assets held by the pension funds. Novy-Marx and Rauh (2014) calculate that, in the absence of policy changes, pension contributions need to increase by 2.5 times to achieve full funding of the state and local pension plans within the coming thirty years. Lekniute et al. (2017) explore how the contract values of the various

stakeholders in the U.S. state pension sector are affected under the continuation of current and alternative pension policies. They find that it will be hard to avoid the full depletion of the pension assets in the coming decades. Hence, a substantial increase in the pension burden on the states' budgets will be unavoidable if all the pension promises are to be honoured.

Fourth, there exists work that explores the legal protection of pension liabilities. According to Munnell and Quinby (2012) an overwhelming majority of the states protect past accrual of pension entitlements under the state constitution or under contract or property law, while more than half of all the states even protect the future accrual of the current fund participants.

3 Data sources, variables and key statistics

3.1 Data sources

Our data come from several sources. The time period that we can cover as well as the frequency at which we conduct our analysis are dictated by the available data on state pension plans. We use the data from the Public Plans Database (PPD) of the Center for Retirement Research at Boston College (2015) to obtain historical time series on assets, liabilities, unfunded liabilities and funding ratios of pension plans in each state. The data are annual and run from 2001 until 2014.They cover over 150 public pension plans in the U.S., thereby representing 90 percent of all the public funds in terms of both assets and plan membership in the U.S. For our analysis, though, we select only the state plans, excluding the local ones. This leaves us with a sample of 114 plans, still a significant majority (around 90%) in terms of assets and liabilities.[5] A priori there is no reason to believe that the excluded funds have a systematically different funding situation than those in the database or have systematically different characteristics other than that they are usually very small, which is the most likely reason for their exclusion. Given that the database covers almost the entire state pension sector, in the sequel we take all the quantities calculated at the state level as representative for the entire state. If anything, the exclusion of a small part of the state pension sector can be expected to weaken the estimated link between municipal yields and the pension sector's financial health, as the latter can be less precisely gauged when not all funds are represented in the dataset.

The historical time series on the gross state product (GSP) and the state debt we obtain from Chantrill (2015).[6] We obtain monthly financial data, in particular treasury and municipal bond yields for each state from Barclays (2015).

[5] A sensitivity analysis in which we include also the local plans leaves the results unchanged.

[6] These data were gathered from reports from official government sources. Some data points were randomly checked by the authors to confirm their reliability.

3.2 Main variables and their definitions

Many states feature more than one civil servants pension fund. Hence, in calculating our various measures of the state level pension liabilities, we aggregate the liabilities across all the funds of the state in the PPD. Analogously, we arrive at our measures of the state's pension assets by aggregating the assets of all the state's pension funds. A state's funding ratio is then obtained as the ratio of the state's pension assets over the state's pension liabilities, and the unfunded liabilities are calculated as the difference between the state's liabilities and the state's assets.

The main variables (almost) directly obtained from our data sources are:

- YM_{it} = municipal yield. The Barclays Municipal Bond Index for each state is a broad-based[7] benchmark that measures the investment grade, US dollar-denominated, fixed-interest tax-exempt municipal bond market. It is a market-value weighted index engineered for the long-term tax-exempt bond market, with an average maturity of 14 years;
- YT_{it} = yield on federal treasury debt. We consider public obligations of the U.S. federal government with a remaining maturity of one year or more. The average remaining maturity is nine years. The state dimension in the subscript arises because we take end-of-the-fiscal-year yields, while the fiscal year end varies across the states. The year t treasury yield is the same for states with identical fiscal years;
- FRa_{it} = the state's "actuarial pension funding ratio" as reported in the PPD, calculated as the state's actuarial pension assets over the state's actuarial liabilities. Actuarial pension assets depend on their own lagged value, net money flows (contributions minus benefit payments) and the returns on the existing assets. Essentially, they smooth over time the fluctuations in the market values of the assets. The actuarial liabilities are calculated as the present value of the future pension payments projected on the basis of the fund's actuarial assumptions;
- $IDRa_{it}$ = the "actuarial implicit debt ratio", i.e. the state's pension plans' unfunded actuarial liabilities, calculated as the difference between the state's actuarial liabilities and the state's actuarial assets, divided by its gross state product (GSP);
- EDR_{it} = the state's "explicit debt ratio", i.e. the state's outstanding explicit debt as a ratio of its GSP.

Pension funds use the actuarial value of their assets to report their funding situation. However, investors are likely to be more interested in the market value of the pension assets.[8] We therefore calculate the alternative measures FRm_{it} and $IDRm_{it}$ that are defined analogously to FRa_{it}

[7] It is designed to reflect the entire market.

[8] Market values of pension assets are not always available during the initial years of the sample. In those cases we use actuarial asset values instead. However, this concerns only a total of seven observations.

and $IDRa_{it}$, except that market asset values replace actuarial asset values in the calculation of these measures.

The liabilities reported in the PPD are the actuarial liabilities. A potentially important issue is the imperfect comparability of the financial health of the state pension funds when the financial health is measured by the officially reported figures. Therefore, to maximize comparability we recalculate the pension fund liabilities on the basis of some common assumptions.

Pension funds have substantial discretion regarding their actuarial assumptions and, in particular, regarding the rate at which they can discount their future benefit payments. The latter is usually based on the expected return on their assets. However, because expected returns are unobservable, views about the appropriate assumptions about the expected returns differ widely, so that naturally there is leeway in the particular discount rate chosen to calculate the fund's liabilities.[9] Hence, different plans may apply different discount rates to calculate their liabilities. However, from a theoretical perspective applying different rates to discount future benefit payments would only be justifiable if the risks associated with the pension benefits are different. A priori we have no reason to assume that the various states' pension promises differ in terms of their legal hardness. In our re-calculation of the pension liabilities, we therefore apply the same discount rate across all the states.

Brown and Pennacchi (2015) argue that the correct discount rate is the risk-free rate as future pension promises can be considered to be hard obligations. Accordingly, Novy-Marx and Rauh in their articles (Novy-Marx and Rauh (2009, 2011)) calculate the pension promises using treasury rates instead of the actuarial discount rate. Hence, below we will report estimates based on using the treasury rate to calculate pension liabilities. However, we will also report estimates based on liabilities calculated using a fixed discount rate of 8%. In practice, this is approximately the median of the expected portfolio returns assumed by pension funds and used to discount their future benefit payments.

Using these two alternative discount rates, we obtain a range for the plausible effect of the implicit pension debt on the municipal yield. Hence, our analysis provides us with an order of magnitude of the potential effect rather than some specific point estimate. This approach seems the more appropriate one in view of the fact that we do not know the true amount of risk associated with current and future pensions, which we implicitly allow to range from zero to that on the typical fund asset portfolio. In fact, many experts would nowadays consider an expected return of 8% on the pension fund's assets to be too high, suggesting that the range for estimated effect on the municipal yield is comfortably wide.

To ensure the comparability of the liabilities across the pension funds we recalculate the liabilities of a specific fund as $L^* = L(1 - (r_d - r_a)D)$[10], where L are the fund's GASB liabilities

[9] In fact, Andonov et al. (2016) find that more poorly funded pension plans tend to take more investment risk, because this allows them to increase the rate at which they can discount future benefit payments, thereby optically improving the plan's financial health.

[10] We use the first-order approximation of the interest rate effect on the liabilities, as this level of precision

reported in the PPD, L^* are the fund's recalculated liabilities, r_d is the common discount rate that we apply to all the pension funds, r_a is the actuarial discount rate applied by the specific fund under consideration and D is the duration of the fund's liabilities.[11,12] We use the estimates of the durations of the pension liabilities obtained in Rauh (2016). For a small number of plans for which this information is missing we set the duration to 10.4 years, which is the average in Rauh's sample. The liability adjustment means that funds that use an actuarial discount rate higher than the common discount rate r_d will have recalculated liabilities that exceed their reported liabilities, while those that use a lower actuarial discount rate will have recalculated liabilities lower than their reported liabilities.

Combining our recalculated liabilities based on a common discount rate with the market values of the funds' assets, we calculate two values for the new funding ratio, one based on a discount rate of 8% and the other based on the treasury yield. Analogously, dividing the difference between the recalculated liabilities and the market value of the assets by the GSP, we obtain two values for the implicit debt ratio. Likewise, we also obtain measures of the funding ratio and the implicit debt ratio based on the actuarial asset values and the recalculated liabilities.

3.3 Descriptive statistics

Our sample consists of all the 50 U.S. states over the period 2001-2014, although for a couple of states not all financial figures are available for the years 2001-2005. Table 1 summarises the data pooled across all the observations in our sample. The average municipal yield of 3.7 percent exceeds the average treasury yield of 3.0 percent. This likely is the net effect of differences in default risk and liquidity, as well as potential differences in the tax treatment of the two types of assets. The average funding ratio of 80 percent based on a common 8 percent discount rate already indicates a substantial average degree of underfunding, but still creates a picture that is far more optimistic than when liabilities are recalculated using the treasury yield. In this case the average funding ratio is only slightly over 50 percent. The average explicit debt ratio of 7.4 percent exceeds the average implicit debt ratio of 4.5 percent based on a common discount rate of 8 percent, but is lower than the implicit debt ratio of 15.8 percent based on the treasury yield. These figures hide substantial variation across the states. The maximum implicit debt ratio of 17.3 percent using 8 percent discounting is close to the maximum of 20.4 percent for the explicit debt ratio, while the maximum implicit debt ratio based on the treasury yield is more than twice as high. However, there are also instances of substantial overfunding, as

should be sufficient for our purposes.

[11]The data on the actuarial discount rates in the PPD database are not complete due to some missing observations for certain years in a number of plans. However, across all the cases for which this information is available, the actuarial discount rate is found to be very stable over time for a given plan. Hence, we impute the missing values for the actuarial discount rates with the observations before or after the years for which an actuarial discount rate is missing.

[12]By duration we refer to the modified duration measure which captures the price sensitivity to interest rates.

indicated by funding ratios substantially above one or negative implicit debt ratios. However, these instances are concentrated in the pre-crisis period before 2008.

Table 1: Descriptive statistics

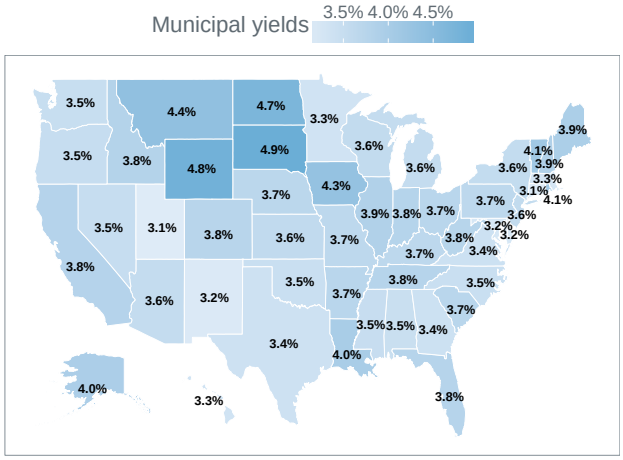
Statistic	N	Mean	St. Dev.	Min	Max
Municipal yield	686	0.037	0.008	0.015	0.064
Treasury yield	686	0.030	0.014	0.008	0.052
Funding ratio (market assets, 8% disc.)	686	0.795	0.184	0.412	1.648
Funding ratio (market assets, treasury disc.)	686	0.520	0.145	0.261	1.051
Implicit debt ratio (market assets, 8% disc.)	686	0.045	0.043	−0.079	0.173
Implicit debt ratio (market assets, treasury disc.)	686	0.158	0.085	−0.004	0.429
Explicit debt ratio	686	0.074	0.037	0.015	0.204

Note: The statistics are calculated over all the observations in the sample. The sample period is 2001–2014. The treasury yield is based on the state-specific fiscal year end. Pension liability calculations are based on the common discount rate indicated in the first column.

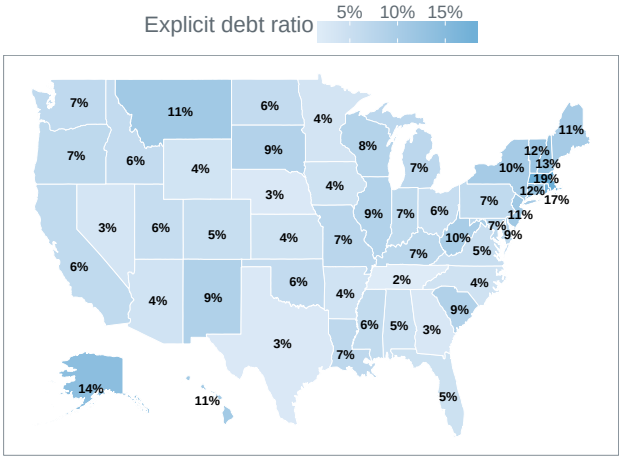
To get an impression of the variation in the key figures across the states, Figure 2 depicts by state the averages over 2001–2014 of the municipal yield, the explicit debt ratio, the state's pension funding ratio and the implicit debt ratio. Average municipal yields range from 3.1% in Utah to 4.9% in South Dakota, while the average explicit debt ratio reaches a maximum of 19% in Massachusetts. This is substantially lower than the public debt ratios of most OECD countries. However, the revenue base at the U.S. state level is smaller than the revenue base at the national level of most OECD countries. As far as the financial health of the state pension sector is concerned, we observe that, based on discounting against a fixed 8 percent rate, funding ratios range from 55 percent in Connecticut to 121 percent in Washington. However, only a handful of states have funding ratios that exceed 100 percent, while if we apply discounting against the treasury yield all the funding ratios are well below 100 percent. In fact, several states have a funding ratio less than 40 percent. The implicit debt ratio ranges from -2 percent in North Carolina to 11 percent in Mississippi when calculated on the basis of a fixed 8 percent discount rate, while in the case of discounting against the treasury yield, the implicit debt ratio is always positive and ranges from 6 percent in Washington to 28 percent of gross state product in Ohio.

Figure 3 depicts the total changes in the key variables between 2001 and 2014 for each state. We observe that municipal yields have fallen everywhere, although by varying amounts. The smallest is a fall by 1.3 percentage points in Nebraska and the largest a fall by 3.0 percentage points in Alaska. The pattern regarding the explicit debt ratios is more mixed, with some states experiencing a fall, although most states have seen their explicit debt ratio rise over the sample period. The financial health of the state pension sectors, when measured against a funding ratio based on 8 percent discounting, has deteriorated in most of the states, although some states saw an improvement. Changes range from a rise by 35 percentage points in West Virginia to a fall by 60 percentage points in Washington. However, when measured against the treasury yield, all but two states experienced a fall in the funding ratio. The maximum fall is over 60 percentage points in Washington state, which had a high funding ratio to start with.

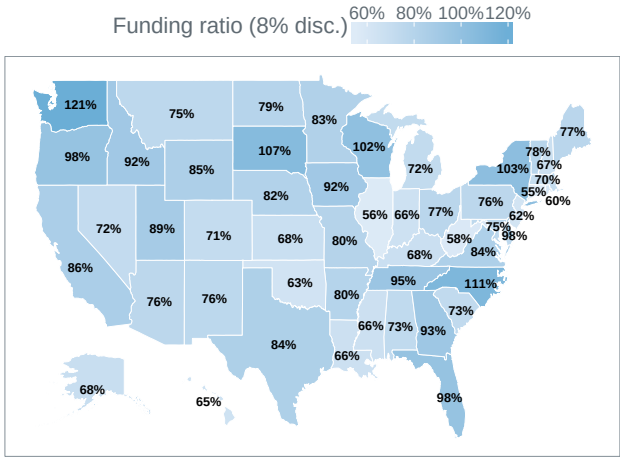
Figure 2: Average values of key variables over the period 2001-2014



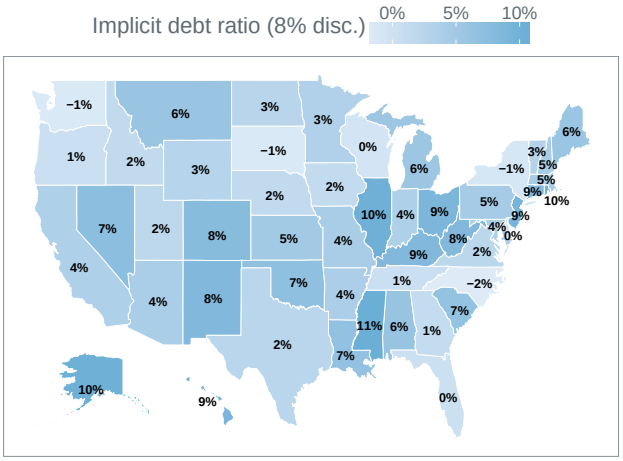
(a) Municipal yields



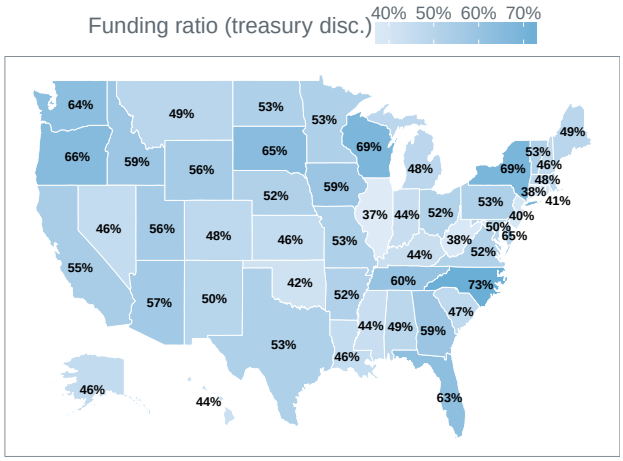
(b) Explicit debt ratio



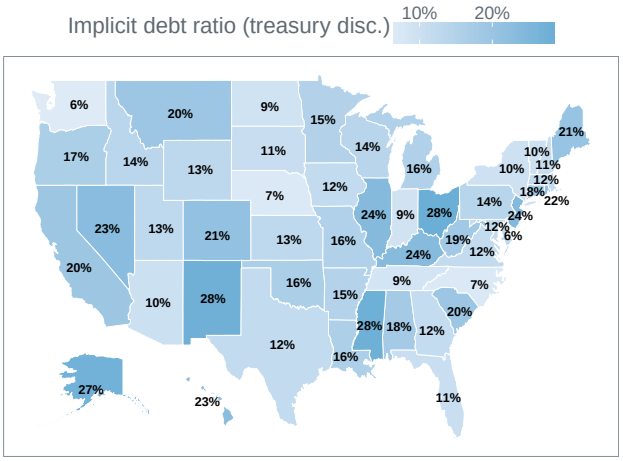
(c) Funding ratio (8% discounting)



(d) Implicit debt ratio (8% discounting)



(e) Funding ratio (treasury discounting)



(f) Implicit debt ratio (treasury discounting)

Note: Darker shades indicate larger numbers. Alaska and Hawaii have been rescaled and moved for a more compact display. When data is not available for the first couple of years in some states, averages are calculated over the shorter time period for which the data are available.

The relatively worse development of the funding ratios under treasury discounting is due to the fall of the treasury yield over the sample period. Finally, we see that the changes in the implicit debt ratios based on 8 percent discounting range from a fall by 7 percentage points in Oregon to an increase by 13 percentage points in Alaska. Most of the states have experienced a rise in the implicit debt ratio, though. Based on treasury discounting the picture is even more pessimistic. Now, all the states have experienced a rise in their implicit debt ratio, with increases ranging from 1 percentage point in Oklahoma to 28 percentage points in Alaska.

Figure 4 depicts how municipal yields and the treasury yield have developed over time. In some years before the crisis the average municipal yield was even lower than the treasury yield. The likely reason is that interest earnings on municipal bonds are tax exempt, whereas those on treasury debt are not. However, since the start of the financial crisis municipal yields are uniformly higher than treasury yield. Below we will present empirical results for both the full 2001–2014 sample period and, in view of the marked changes since the start of the crisis, the pre-crisis sub-sample period 2001-2007 and crisis sub-sample period 2008-2014.

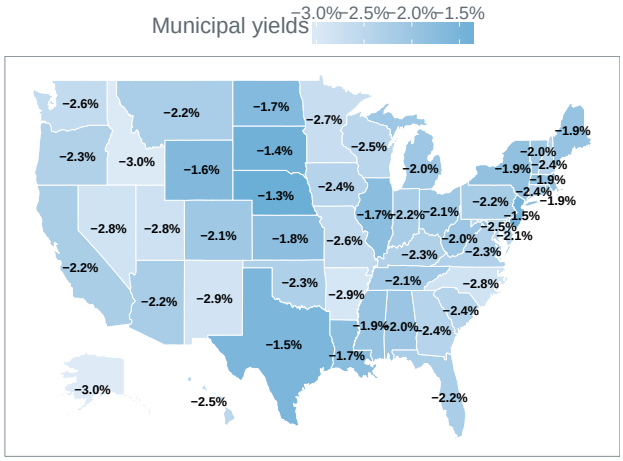
Table 2 reports the correlations between a number of key variables. First, not surprisingly, municipal and treasury yields exhibit a high positive correlation. Second, funding ratios are positively correlated with both treasury and municipal yields, while the implicit pension debt ratio is negatively correlated with both yields. The correlations with the municipal yield seem paradoxical if we expect that a weaker financial health of the state pension sector pushes up municipal yields on the state's explicit debt. However, the correlation patterns are explained by the fact that since the start of the crisis yields on both state and federal debt have been on a downward trend following the Fed's expansionary monetary policy measures, while at the same time the financial health of the state pension sector has been declining. Hence, the correlations merely seem to be picking up the co-movement of two trends that are not directly related with each other. The trends also explain the relatively high positive correlation between the implicit and explicit debt ratios and the relatively strong negative correlation between the latter variable and the funding ratio. Finally, as expected, the implicit debt ratio and the pension funding ratio are highly negatively correlated.

Table 2: Correlation matrix of key variables over all observations

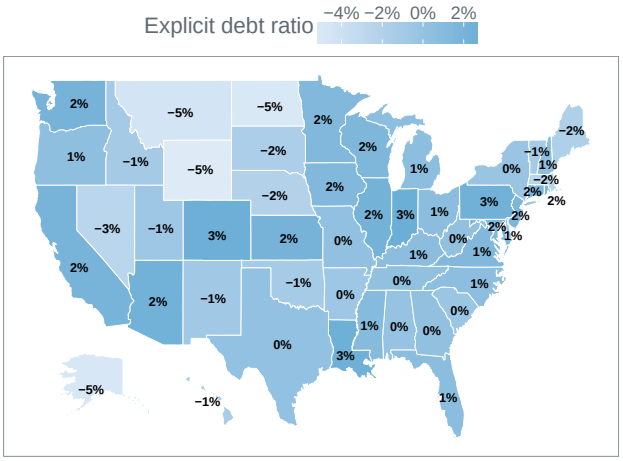
	Municipal yield	Treasury yield	FR (8% disc.)	FR (treasury disc.)	IDR (8% disc.)	IDR (treasury disc.)	Explicit debt ratio
Municipal yield	1	0.72	0.19	0.43	-0.19	-0.42	0.03
Treasury yield	0.72	1	0.36	0.70	-0.34	-0.61	-0.04
FR (8% disc.)	0.19	0.36	1	0.89	-0.90	-0.66	-0.31
FR (treasury disc.)	0.43	0.70	0.89	1	-0.82	-0.76	-0.23
IDR (8% disc.)	-0.19	-0.34	-0.90	-0.82	1	0.85	0.32
IDR (treasury disc.)	-0.42	-0.61	-0.66	-0.76	0.85	1	0.22
Explicit debt ratio	0.03	-0.04	-0.31	-0.23	0.32	0.22	1

Note: The correlations are calculated over all observations in the sample. Sample period is 2001–2014. Funding ratio and implicit debt measures are based on market values of assets.

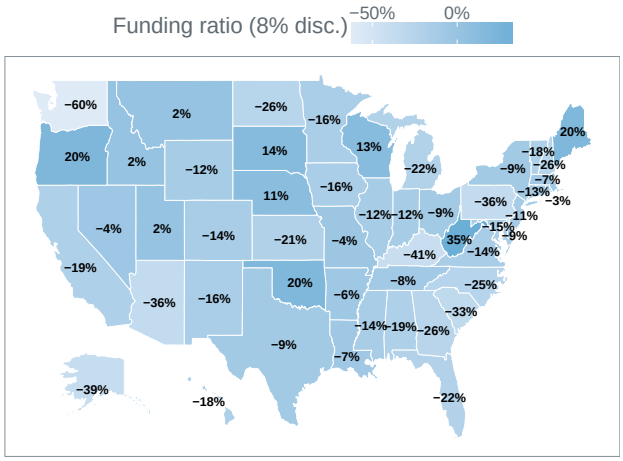
Figure 3: Percentage point changes in the key variables over the period 2001-2014



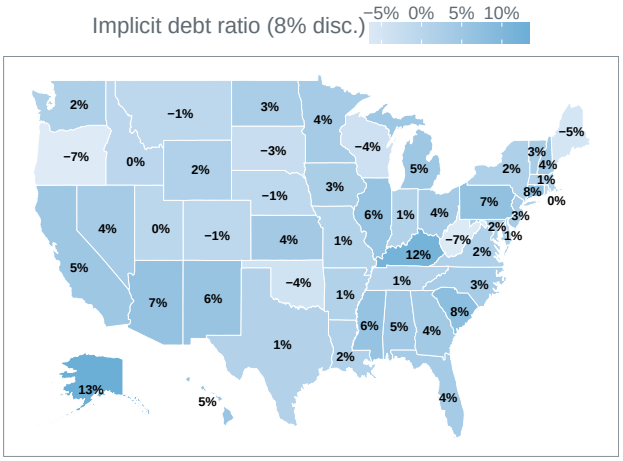
(a) Municipal yields



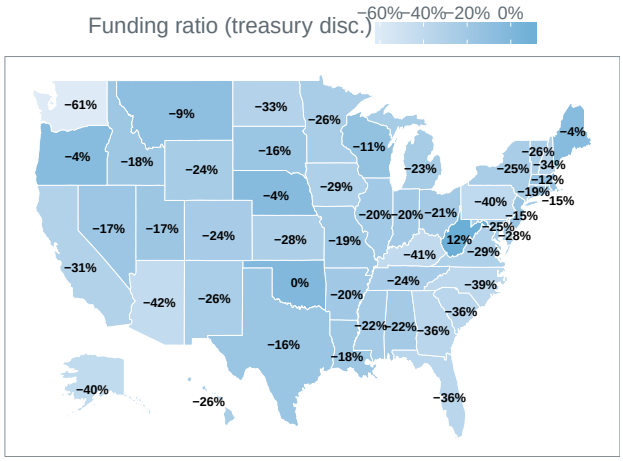
(b) Explicit debt ratio



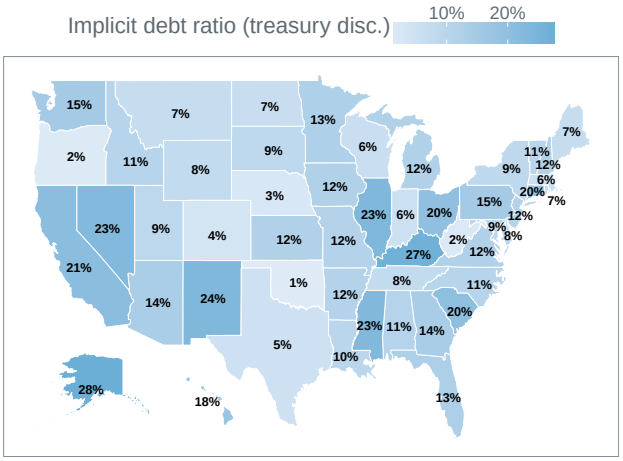
(c) Funding ratio (8% discounting)



(d) Implicit debt ratio (8% discounting)



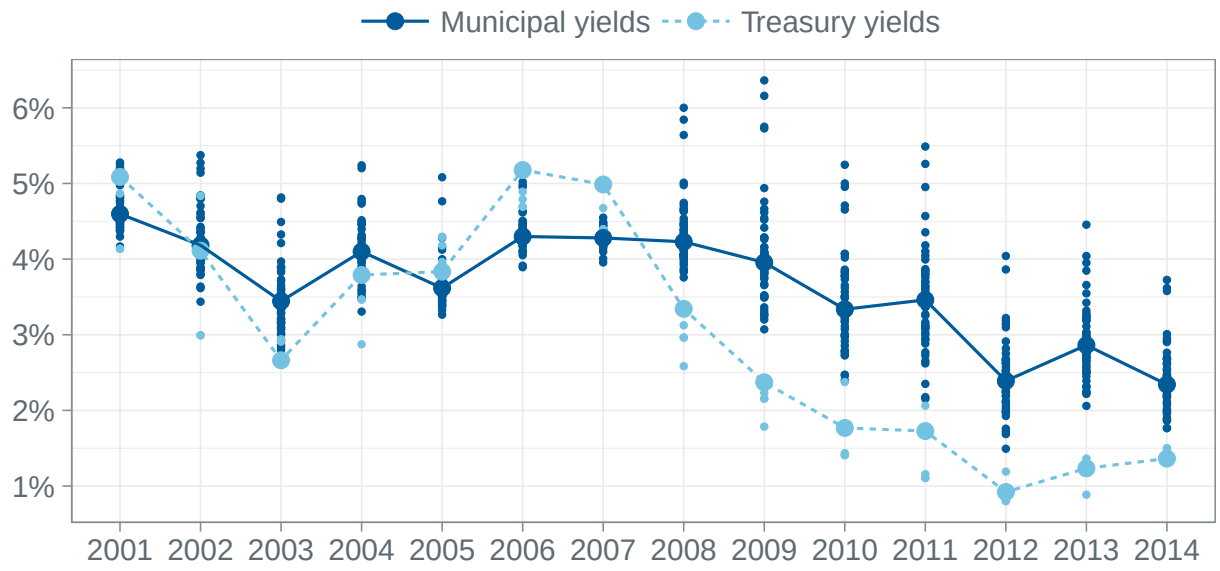
(e) Funding ratio (treasury discounting)



(f) Implicit debt ratio (treasury discounting)

Note: Darker shades indicate larger numbers. Alaska and Hawaii have been rescaled and moved for a more compact display. For some states the data are not available for the first couple of years. In those cases changes are calculated for the period during which the data are available. The changes are reported in percentage points.

Figure 4: Municipal and treasury yields over the sample period



Note: The small dots represent observations for each individual state, while the large connected dots show the median rates for each sample year. Note that each year features multiple observations for the treasury yield corresponding to the different ends of the state fiscal years.

4 Results

4.1 Baseline results

We stay as close as possible to the existing literature, by including in the regression for the municipal yield state-specific fixed effects to account for all the unobserved differences among the states leading to systematic differences in the municipal yields, the yield on the federal debt to control for general yield movements primarily caused by monetary policy, and the explicit debt ratio. Our main extension of the standard framework is to include measures of the financial health of the civil servants' pension sector in each state. Hence, in its most general format our baseline regression equation reads:

$$YM_{it} = \alpha_i + \beta_1 YT_{it} + \beta_2 EDR_{it} + \beta_3 FR_{it} + \beta_4 IDR_{it} + \epsilon_{it},$$

where FR and IDR can be any of the variants of the funding ratio and the implicit debt ratio defined in Section 3.2, and α_i denotes the state fixed effects that account for all the time invariant differences among the states. While municipal yields are expected to depend strongly on treasury yields, they may differ from the latter to the extent that investors perceive them as carrying higher default risk (one reason being that states cannot print money to pay off their debt), more liquidity risk or for other reasons, such as a difference in the tax treatment of their returns. We would expect the repayment risk of municipal debt to depend on its own size as well as the financial health of the civil servants' pension funds, because the state is liable for

the provision of the pensions of its civil servants. The recent Detroit bankruptcy case suggests that there does not exist an unambiguous seniority ranking between the explicit debt and the pension debt, which confirms that a full write off of the pension liabilities before any explicit debt is written off is extremely unlikely, implying that a higher implicit debt raises the expected default losses on the explicit debt.

In our baseline regressions we include measures of the pension sector's financial health based on the market value rather than the actuarial value of the pension assets, because a priori we expect market values to be a better indicator of the capacity to cover the future pension benefits. In our regressions we will never include measures of the funding ratio and the implicit debt ratio simultaneously as explanatory variables, because the two are highly (negatively) correlated alternative measures of the financial health of the pension sector. A priori, we would expect the implicit debt ratio to be the more relevant variable for the municipal yield, because a low funding ratio in a state with a relatively small civil servants' pension sector would in itself carry no repayment threat for the explicit debt. The other advantage of using the implicit debt variable is that it is measured in the same units as the explicit debt ratio and, hence, we can directly compare the effect on the municipal yield of a one-percentage point increase in the implicit debt ratio with that of a one-percentage point increase in the explicit debt ratio.

Table 3: Baseline regressions for municipal yields

	Dependent variable:				
	Municipal yield				
	(1)	(2)	(3)	(4)	(5)
Treasury yield	.426***	.508***	.610***	.493***	.520***
	(.017)	(.018)	(.033)	(.019)	(.030)
EDR	.083***	.058**	.060***	.064**	.072***
	(.021)	(.024)	(.023)	(.026)	(.024)
FR market assets, 8% disc.		−.018***			
		(.003)			
FR market assets, treasury disc.			−.027***		
			(.005)		
IDR market assets, 8% disc.				.068***	
				(.012)	
IDR market assets, treasury disc.					.026***
					(.007)
Model	FE	FE	FE	FE	FE
Observations	686	686	686	686	686
R^2	.674	.718	.718	.710	.686
Adjusted R^2	.623	.663	.662	.655	.633

Note: * is p-value <0.1; ** is p-value <0.05; *** is p-value <0.01.
FE indicates inclusion of state-fixed effects. Sample period is 2001–2014.

Table 3 reports the estimates for the baseline regression specification.[13] Column (1) presents the estimates when only the explicit debt ratio, but no measure of the pension sector's financial health, is included. The effect of the explicit debt ratio is significant at the 1% level. A one percentage point increase in the state debt ratio raises the municipal yield by 8 basis points. The ensuing two regressions include a measure of the financial health of the state pension sector. Columns (2) and (3) show that, while the explicit debt ratio remains significant at the 1 percent level, the state level funding ratio is significant at this level too. However, the coefficient on the explicit debt ratio is slightly smaller now, and suggests a 6 basis points rise in the municipal yield for a one percentage point increase in the explicit debt ratio. A one percentage point reduction in the funding ratio raises the municipal yield by 1.8 basis points in the case of discounting against an 8 percent fixed rate and by 2.7 basis points when the treasury yield is used. The coefficient is larger in abosolute terms in the latter case, because the treasury yield is always lower than 8 percent, implying uniformly lower funding ratios. Overall, even though the funding ratio may be a less-than-perfect indicator of the difficulty to repay the explicit debt, it still exerts a statistically and economically significant effect on the municipal yield.

Columns (4) and (5) replace the funding ratio with the implicit pension debt ratio. Both the explicit debt ratio and the implicit debt ratio are significant, irrespective of the discount rate used to calculate the implicit debt ratio. The point estimate of the coefficient on the implicit debt ratio when using the 8 percent discount rate is of a magnitude similar to that on the explicit debt ratio. It indicates that a one-percentage point increase in the implicit debt ratio raises the municipal yield by 6.8 basis points as opposed to an increase of 6.4 basis points for a one-percentage point increase in the explicit debt ratio. However, with liabilities discounted at the treasury yield, the coefficient on the implicit debt ratio yields a smaller effect of 2.6 basis points, which is still highly significant, though. The reduced size of the effect is the result of the higher implicit debt ratios produced with a discount rate that is substantially lower on average. Overall, our baseline estimate is a municipal yield increase ranging from 2.6 to 6.8 basis points for a one percentage point increase in the implicit debt ratio.

4.2 Subperiods

The recent economic and financial crisis has potentially caused large shifts in economic relationships. Figure 4 suggests that the relationship between municipal yields and the treasury yield has changed since the start of the crisis, indicating a possible regime switch. Therefore, in this subsection we split the full sample into two subsamples: the subperiod 2001 – 2007 before the full eruption of the recent economic and financial crisis and the subperiod 2008 – 2014 since

[13] We report the within R^2 and cluster-robust standard errors that account for serial correlation. We also calculated standard errors adjusted for cross-sectional correlation. The coefficients on our debt measures remained significant. However, due to the fact that our data contain fewer time periods than states, applying this adjustment is formally not correct and, therefore, we report the standard errors adjusted for serial correlation.

the start of the crisis. We refer to the former sub-period as the "pre-crisis period" and to the second sub-period as the "crisis period". Table 4 reports the regressions for the period before the crisis, whereas Table 5 reports the results for the crisis period. Columns (1) to (5) represent regression models analogous to those in Table 3. The pre-crisis estimates are significant only for implicit debt ratio and only at the 10 percent level, while the crisis estimates are highly significant for both the explicit and implicit debt ratio (as well as the funding ratio). Compared to the full-sample estimates, the point estimates of the coefficient on the explicit debt ratio have increased substantially and have become larger than the estimate of the coefficient on the implicit debt ratio. The regression reported in Column (4) in Table 5 suggests that a one percentage point increase in the explicit debt ratio during the crisis period raises the municipal yield by 14.9 basis points, while an increase in the implicit debt ratio based on a common 8% discount rate for the calculation of the liabilities now raises the municipal yield by 7.5 basis points. When liabilities are calculated using the treasury yield (Column (5)), these effects become 17.7 and 4.0 basis points respectively. The outcomes suggest that, while there was little awareness of state indebtedness when pricing the municipal bonds before the crisis, this has changed with the crisis. The smaller effect of the implicit debt ratio relative to that of the explicit debt ratio may indicate that investors view pension promises as easier to renege upon, hence legally less hard to enforce than explicit debt obligations, or that they expect that effective measures, such as an increase in the contributions by the pension fund participants, can be taken in time to reduce the burden of the pension obligations on the public budget.

We can make a back-of-the-envelope calculation of the long-run effect on the state budget of a one-percentage point increase in the implicit debt ratio, assuming that the explicit debt ratio is held constant. In the long run all the explicit debt will have been rolled over and, hence, the effect of the rise in the implicit debt will by then have been incorporated in the interest payments on all the outstanding explicit debt. Our calculation will be based on the estimates for the crisis period.

Using the average implicit debt ratio of 4.5 percent from Table 1 and the estimated 7.5 basis points yield increase for each percentage point increase in the implicit debt ratio (with discounting against a fixed 8 percent rate) from Table 5, we calculate an average 34 basis points yield increase that can be attributed to the existence of pension deficits.[14] Given that the average municipal yield is 3.7 percent, states would need to pay more than 9 percent extra in interest costs (assuming that the yield equals the interest rate on the debt). When treasury yield discounting is used, our estimates translate into a yield increase of 15.8×4.0 is 63 basis points, or around 17 percent of the interest cost. Hence, an underfunded pension system may come at a substantial debt-servicing cost.

Because the effect of an increase in the implicit pension debt on municipal yields appears to be limited to the crisis period, the remainder of our analysis will focus on the crisis period only.

[14]These calculations neglect potential non-linear effects in the yield response when the implicit debt ratio is raised by a large amount.

Table 4: Baseline regressions – pre-crisis period

	Dependent variable:				
	Municipal yield				
	(1)	(2)	(3)	(4)	(5)
Treasury yield	.395***	.410***	.428***	.412***	.432***
	(.020)	(.022)	(.032)	(.021)	(.026)
EDR	−.055	−.055	−.055	−.054	−.057*
	(.037)	(.036)	(.036)	(.036)	(.035)
FR		−.003			
market assets, 8% disc.		(.003)			
FR			−.004		
market assets, treasury disc.			(.004)		
IDR				.018*	
market assets, 8% disc.				(.010)	
IDR					.012*
market assets, treasury disc.					(.007)
Model	FE	FE	FE	FE	FE
Observations	337	337	337	337	337
R^2	.640	.642	.642	.644	.644
Adjusted R^2	.541	.541	.541	.543	.542

Note: * is p-value <0.1; ** is p-value <0.05; *** is p-value <0.01.
FE indicates inclusion of state-fixed effects. Sample period is 2001–2007.

Table 5: Baseline regressions – crisis period

	Dependent variable:				
	Municipal yield				
	(1)	(2)	(3)	(4)	(5)
Treasury yield	.805***	.826***	.930***	.825***	.922***
	(.023)	(.023)	(.031)	(.024)	(.035)
EDR	.226***	.149***	.152***	.149***	.177***
	(.034)	(.028)	(.028)	(.029)	(.032)
FR		−.019***			
market assets, 8% disc.		(.002)			
FR			−.031***		
market assets, treasury disc.			(.004)		
IDR				.075***	
market assets, 8% disc.				(.012)	
IDR					.040***
market assets, treasury disc.					(.008)
Model	FE	FE	FE	FE	FE
Observations	349	349	349	349	349
R^2	.809	.845	.844	.839	.822
Adjusted R^2	.688	.716	.716	.712	.697

Note: * is p-value <0.1; ** is p-value <0.05; *** is p-value <0.01.
FE indicates inclusion of state-fixed effects. Sample period is 2008–2014.

To save space we limit ourselves in addition to the case in which pension liabilities are based on discounting against the treasury yield. This yields a lower bound on the effect of a change in the implicit debt ratio on the municipal yield. All results are qualitatively confirmed when we use a common 8% discount rate, while the estimated size of the effect of the implicit debt ratio increases.

4.3 Robustness

This subsection explores in a variety of ways the robustness of the baseline estimates.

4.3.1 Reporting lag

In our baseline regressions all the yields correspond to the end of the state's fiscal year. However, pension funds may take some time to report their figures. Hence, the more relevant moment to measure the effect of the pension sector's financial health on municipal yields could potentially be the reporting moment. Reporting moments across pension funds differ. In Table 6 we therefore rerun our key regressions, while taking both municipal and treasury yields corresponding to the end of the fiscal year plus 1 or 2 months. For easier comparison, we repeat regressions (3) and (5) from Table 5. We observe that the coefficients on the funding ratio and the implicit debt ratio remain (highly) significant, although their absolute magnitude gradually falls if we shift the reporting moment further away from the end of the fiscal year. This may not be surprising: the market values of the pension funds' assets and liabilities can be monitored continuously and, hence, the relevant information of the pension sector's financial health should be available by the end of the fiscal year. In other words, the reporting of the figures after the end of the fiscal year releases relatively little new information.

Table 6: Robustness – reporting lag

	Dependent variable:					
	Municipal yield					
	no lag		1 month lag		2 months lag	
	(1)	(2)	(3)	(4)	(5)	(6)
Treasury yield	.930***	.922***	.850***	.833***	.825***	.800***
	(.031)	(.035)	(.029)	(.034)	(.031)	(.036)
EDR	.152***	.177***	.174***	.196***	.161***	.183***
	(.028)	(.032)	(.028)	(.031)	(.031)	(.033)
FR	−.031***		−.021***		−.019***	
market assets, treasury disc.	(.004)		(.004)		(.004)	
IDR		.040***		.024***		.017**
market assets, treasury disc.		(.008)		(.008)		(.008)
Model	FE	FE	FE	FE	FE	FE
Observations	349	349	349	349	349	349
R^2	.844	.822	.775	.763	.695	.684
Adjusted R^2	.716	.697	.658	.647	.589	.580

Note: * is p-value <0.1; ** is p-value <0.05; *** is p-value <0.01.
FE indicates inclusion of state-fixed effects. Sample period is 2008–2014.

4.3.2 Alternative liability estimates

This subsection explores the robustness of our results for different assumptions underlying the recalculation of the liabilities. Since using the duration data of Rauh (2016) leaves us with several missing observations for which we imputed the average duration in that sample, we want to explore the sensitivity of our results to the duration assumption.

For that reason we use alternative common durations of 7.5, 10 and 15 years. Hence, in the baseline regression we replace the funding and implicit debt ratios based on plan-specific durations with the corresponding measures based on a common duration. If the results remain robust, allowing for a wide range of common durations, we can be comfortable with our baseline results. Table 7 reports the results. We observe that our results are entirely robust with respect to the assumed liability duration. Obviously, assuming a longer duration blows up the liabilities and, hence, results into coefficient estimates of the funding ratio that are somewhat larger in absolute value and coefficient estimates of the implicit debt ratio that are somewhat smaller.

4.3.3 The treatment of the fiscal years

The state fiscal years do not correspond to the calendar year. In most states the fiscal year ends on June 30, whereas it ends on March 31 in New York, August 31 in Texas and September 30 in Alabama and Michigan. Since our pension plan data are generally recorded at the end of the fiscal year, for each state we take the end-of-the-fiscal-year municipal and treasury yields corresponding to the fiscal year for that state.

However, seventeen plans in our sample report their figures at a different moment than the end of the state fiscal year. For most states these plans constitute a minority in terms of liabilities, but there are four states in which all the plans report at the end of the calendar year as opposed to the state's official fiscal year end. Table 8 shows the regression outcomes if we use yields corresponding to the end of the own reporting year adopted by the majority of the plans in the state. The estimates are rather close to those reported in Table 5. Because the estimates barely change, in the sequel we continue to use the yields of the end of the states' fiscal years.

4.4 Extensions

In this subsection we consider some extensions of the baseline regression.

4.4.1 Non-linear effects of the pension funds' financial health

It is conceivable that investors react differently to an improvement in the funding situation of the pension sector when the funding situation is very unfavorable than when it is favorable.

Table 7: Robustness – liabilities based on alternative common durations

	Dependent variable:					
	Municipal yield					
	(1)	(2)	(3)	(4)	(5)	(6)
Treasury yield	.912***	.925***	.946***	.917***	.926***	.931***
	(.029)	(.030)	(.032)	(.033)	(.035)	(.038)
EDR	.152***	.152***	.152***	.167***	.173***	.182***
	(.028)	(.028)	(.028)	(.031)	(.032)	(.033)
FR duration of 7.5	−.028***					
	(.004)					
FR duration of 10		−.030***				
		(.004)				
FR duration of 15			−.035***			
			(.005)			
IDR duration of 7.5				.051***		
				(.009)		
IDR duration of 10					.044***	
					(.009)	
IDR duration of 15						.033***
						(.007)
Model	FE	FE	FE	FE	FE	FE
Observations	349	349	349	349	349	349
R^2	.844	.844	.844	.827	.824	.820
Adjusted R^2	.716	.716	.716	.702	.699	.696

Note: * is p-value <0.1; ** is p-value <0.05; *** is p-value <0.01.
FE indicates inclusion of state-fixed effects. Sample period is 2008–2014.
FR and IDR measures are calculated with market assets and treasury discounting using the specified duration.

Table 8: Robustness – yields based on the end of the own reporting year of the majority of the plans in a state

	Dependent variable:		
	Municipal yield		
	(1)	(2)	(3)
Treasury yield	.793***	.968***	.946***
	(.024)	(.036)	(.041)
EDR	.245***	.147***	.183***
	(.042)	(.031)	(.041)
FR		−.040***	
market assets, treasury disc.		(.005)	
IDR			.049***
market assets, treasury disc.			(.010)
Model	FE	FE	FE
Observations	349	349	349
R^2	.727	.779	.746
Adjusted R^2	.618	.661	.633

Note: * is p-value <0.1; ** is p-value <0.05; *** is p-value <0.01.
FE indicates inclusion of state-fixed effects. Sample period is 2008–2014.

The reason is that an improvement in an already healthy funding situation has only little effect on the chance that the government at some point in the future will need to supply additional resources to honor the pension obligations at the expense of its debt-servicing obligations. The opposite is the case when the funding situation is weak to start with. To investigate this possible non-linearity in the relationship between the pension sector's financial health and the municipal yield, we explore whether the coefficients on the funding ratio and the implicit debt ratio are larger in absolute value when the funding ratio is relatively low than when it is relatively high. Hence, we interact the funding ratio or the implicit debt ratio with a dummy D_{LF}, which equals one (zero) if the funding ratio is below (above) its median value.[15] Table 9 reports the results. In both regressions, the coefficients on the non-interacted terms remain (highly) significant. The specification with the interaction with the implicit debt ratio suggests that the effect of an increase in the implicit debt ratio on the municipal yield is indeed slightly stronger when the financial health of the state pension sector is relatively poor. However, the overall effect of an increase in the implicit debt ratio in this case is slightly smaller than under the baseline.

4.4.2 State-specific time trends and treasury-yield coefficients

There is insufficient variation in our data to include both state and time fixed effects in our model. To the best of our knowledge this should also not be necessary, as there have not been

[15]We calculate the median value across all states and years in our sub sample 2008-2014.

Table 9: Robustness – interaction with funding ratio dummy

	Dependent variable:	
	Municipal yield	
	(1)	(2)
Treasury yield	.930***	.909***
	(.032)	(.036)
EDR	.153***	.175***
	(.028)	(.033)
FR	−.029***	
market assets, treasury disc.	(.004)	
FR × D_{LF}	.001	
	(.002)	
IDR		.026**
market assets, treasury disc.		(.012)
IDR × D_{LF}		.006**
		(.003)
Model	FE	FE
Observations	349	349
R^2	.844	.825
Adjusted R^2	.714	.697

Note: * is p-value <0.1; ** is p-value <0.05; *** is p-value <0.01.
FE indicates inclusion of state-fixed effects. Sample period is 2008–2014.
D_{LF} is a dummy for funding ratio (market assets, treasury yield disc.) below the median.

any significant changes in factors such as tax policy that would need to be captured by time-fixed effects. There was a structural break in bond wrapping starting with the crisis. However, this break is taken care of by splitting our sample into the pre-crisis and crisis subsamples. Nevertheless, we estimate two additional model specifications for the crisis period with alternatives to time effects, namely one in which we include a state-specific time trends (reported in Column (1) in Table 10) and one in which we allow for state-specific coefficients on the treasury yield (reported in Column (2) in Table 10). Both specifications yield coefficients on the implicit debt ratio that are still highly significant. The coefficient on the explicit debt ratio implies municipal yield effects ranging between 11 and 27 basis points for a one percentage point increase in the ratio, while the coefficient on the implicit debt ratio implies yield effects ranging between 3.5 and 4.9 basis points for a one percentage point increase in the ratio. Hence, the coefficients on the implicit debt ratio are very similar to those reported in Table 5.

Table 10: State-specific time trends and treasury-yield coefficients

	Dependent variable:			
	Municipal yield			
	(1)	(2)	(3)	(4)
Treasury yield	.685***	.623***	.957***	.967***
	(.043)	(.040)	(.013)	(.021)
EDR	.105**	.096*	.218***	.274***
	(.050)	(.050)	(.050)	(.051)
FR	−.024***		−.034***	
market assets, treasury disc.	(.004)		(.004)	
IDR		.035***		.049***
market assets, treasury disc.		(.007)		(.010)
Model	state-specific time trend		state-specific YT coeff	
Observations	349	349	349	349
R^2	.886	.881	.873	.858
Adjusted R^2	.625	.621	.618	.607

Note: * is p-value <0.1; ** is p-value <0.05; *** is p-value <0.01.
Sample period is 2008–2014.

4.4.3 Other extensions

It is possible that investors perceive states as belonging to intrinsically different groups and therefore treat them differently in the pricing of their municipal debt. In this section we explore several possible variables as a potential source of a different investor treatment.

We first explore two indicators of the adaptability of the pension system. Table 11 reports regressions that include interaction terms of the financial health of the state pension sector and two dummy variables. Based on Table 2 in Munnell et al. (2014) we introduce a pension

protection variable, which indicates the strength of the legal protection of pensions entitlements. Dummy D_{HP} has a value of one if both the benefits accrued in the past and the benefits to be accrued in the future are legally protected, and a value of zero if no protection is granted or only benefits accrued in the past are protected. The pension flexibility variable is based on Exhibit 1 in Picur and Weiss (2011). It indicates the extent to which pension plans have been adjusted between 2000 and 2010. Adjustment measures captured in the study were increased member contributions, changes in the benefit formula, reduced indexation and a shift to DC or hybrid plans. The dummy D_{HF} takes a value of one if at least two of these measures were implemented in a state's pension plans, and zero otherwise. Conceptually, the two dummies are quite strongly related. However, Dummy D_{HP} takes an ex-ante perspective, while dummy D_{HF} takes an ex-post perspective. A priori we might expect the financial health of the state pension sectors with high protection to have a relatively strong effect on municipal yields, while we might expect the opposite for states with substantial flexibility. However, neither the interaction of our financial health variables with the pension protection dummy nor the interaction with the pension flexibility dummy is significant. The estimates of the coefficients on the other variables remain highly significant and very similar in magnitude to their baseline values.

Our final extensions of the baseline specification include interactions of our state pension sector financial health variables with dummies that provide information on the ability to repay the state explicit debt. The first dummy is D_{HREV}, which is one for states with higher-than-average ratios of public revenues to GSP (measured for the crisis period). The idea is that states with a relatively narrow revenue base may find it relatively hard to raise the revenue needed to honour the pension entitlements and, hence, the danger that the explicit debt cannot be paid off in full is larger. Table 12, Columns (1) and (3) report the results. In neither of the two specifications is the interaction term significant, while the coefficients on the other variables preserve their significance and order of magnitude.[16] The second dummy variable is D_{HRAT}, which is one for states with a relatively high credit rating of AAA or AA+ in 2014, and zero otherwise. The idea is that states with a relatively low credit rating might be under tighter scrutiny from investors, so that a given deterioration of the pension sector's financial health has a stronger effect on the municipal yield. The regression results are found in Columns (2) and (4) of Table 12. Again, the interaction terms are insignificant, while the significance and order of magnitude of the other coefficient estimates is unaffected.

[16]Replacing the dummy-based interaction term with the interaction of the average revenue ratio itself with the funding ratio or the implicit debt ratio has no effect on the results. The interaction term remains insignificant, while the estimates of the coefficients on the other variables are unchanged.

Table 11: Interaction with pension protection and flexibility

	Dependent variable:			
	Municipal yield			
	(1)	(2)	(3)	(4)
Treasury yield	.929***	.933***	.925***	.922***
	(.031)	(.030)	(.037)	(.035)
EDR	.152***	.150***	.176***	.177***
	(.028)	(.028)	(.032)	(.032)
FR	−.033***	−.028***		
market assets, treasury disc.	(.006)	(.005)		
FR × D_{HP}	.002			
	(.006)			
FR × D_{HF}		−.008		
		(.006)		
IDR			.053***	.040***
market assets, treasury disc.			(.014)	(.011)
IDR × D_{HP}			−.017	
			(.013)	
IDR × D_{HF}				−.001
				(.011)
Model	FE	FE	FE	FE
Observations	349	349	349	349
R^2	.844	.845	.823	.822
Adjusted R^2	.713	.714	.696	.695

Note: * is p-value <0.1; ** is p-value <0.05; *** is p-value <0.01.
FE indicates inclusion of state-fixed effects. Sample period is 2008–2014.
D_{HP} is a dummy indicating high pension protection. D_{HF} is a dummy indicating high pension flexibility.

Table 12: Interaction with public revenue base and credit rating

	Dependent variable:			
	Municipal yield			
	(1)	(2)	(3)	(4)
Treasury yield	.933***	.930***	.908***	.922***
	(.036)	(.032)	(.038)	(.036)
EDR	.151***	.148***	.179***	.177***
	(.028)	(.029)	(.032)	(.033)
FR	−.032***	−.036***		
market assets, treasury disc.	(.005)	(.006)		
FR × D_{HREV}	.0003			
	(.001)			
FR × D_{HRAT}		.008		
		(.006)		
IDR			.039***	.039***
market assets, treasury disc.			(.008)	(.010)
IDR × D_{HREV}			−.003	
			(.002)	
IDR × D_{HRAT}				.002
				(.012)
Model	FE	FE	FE	FE
Observations	349	349	349	349
R^2	.844	.845	.823	.822
Adjusted R^2	.713	.714	.696	.695

Note: * is p-value <0.1; ** is p-value <0.05; *** is p-value <0.01.
FE indicates inclusion of state-fixed effects. Sample period is 2008–2014.
D_{HREV} is a dummy indicating high revenues. D_{HRAT} is a dummy indicating a high credit rating.

4.5 Actuarial values

So far, we have used the market values of the assets and the recalculated values of the liabilities (based on a common discount rate across the plans) to calculate the funding ratio and the implicit debt ratio. Reporting by the pension funds themselves and the determination of their policy instruments are most likely driven by the actuarial values of both the assets and the liabilities. The actuarial values of the assets are usually the market values smoothed over several years.

Table 13 reports the regression results for the crisis period 2008 – 2014 when in our measures of the financial health of the state pension sector we replace the market values of the assets with the actuarial values and/or we replace the recalculated liabilities with the reported actuarial values. For easier comparison, in Columns (1) and (5) we repeat the baseline regressions (Columns (3) and (5) from Table 5). Columns (2) and (6) show that only replacing the recalculated liabilities with their actuarial values has little effect on the original results in terms of significance. Because funding ratios are higher and implicit debt ratios are lower when actuarial liabilities are used, the estimated funding ratio coefficient shrinks while the estimated coefficient on the implicit debt ratio rises. Replacing the market values of the assets with the actuarial values (Columns (3) and (7)) has more serious implications. In particular, the estimate of the coefficient on the implicit debt ratio loses significance. As a final step we replace the market values of the assets with their actuarial values and at the same time use the actuarial liabilities. Columns (4) and (8) show that the funding ratio and the implicit debt ratio remain significant, but in both cases the significance is lower than under the baseline. Overall, these results provide an indication that financial market participants rely more strongly on the market values of the pension assets than on actuarial asset values in their assessment of the state pension sector's financial health.

Table 13: Actuarial versus market values

	Dependent variable:							
	Municipal yield							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treasury yield	.930***	.844***	.949***	.861***	.922***	.845***	.830***	.843***
	(.031)	(.024)	(.055)	(.032)	(.035)	(.025)	(.045)	(.030)
EDR	.152***	.152***	.224***	.228***	.177***	.153***	.223***	.223***
	(.028)	(.028)	(.032)	(.032)	(.032)	(.030)	(.033)	(.032)
FR market assets, treasury disc.	−.031***							
	(.004)							
FR market assets, actuarial liab.		−.020***						
		(.003)						
FR actuarial assets, treasury disc.			−.026***					
			(.009)					
FR actuarial assets, actuarial liab.				−.013**				
				(.006)				
IDR market assets, treasury disc.					.040***			
					(.008)			
IDR market assets, actuarial liab.						.077***		
						(.011)		
IDR actuarial assets, treasury disc.							.007	
							(.011)	
IDR actuarial assets, actuarial liab.								.035**
								(.018)
Model	FE	FE	FE	FE	FE	FE	FE	FE
Observations	349	349	349	349	349	349	349	349
R^2	.844	.844	.816	.813	.822	.838	.809	.811
Adjusted R^2	.716	.716	.692	.690	.697	.711	.686	.688

Note: * is p-value <0.1; ** is p-value <0.05; *** is p-value <0.01.
FE indicates inclusion of state-fixed effects. Sample period is 2008–2014.

5 Conclusions

Recent years have seen a steady decline in the funding situation of U.S. state pension plans. As a result the implicit pension debt associated with the states' civil servants pension funds is rising. There exists quite a substantial amount of evidence in the empirical literature that higher explicit public debt raises yields on the public debt by lowering the borrower's creditworthiness. Hence, politicians with short time horizons may be tempted to substitute implicit for explicit debt by paying inadequate pension contributions, as financial market participants might pay less attention to the implicit pension debt. This temptation could be a factor helping to explain the widespread underfunding of the state sector pension plans. However, our estimates suggest that investors, when pricing the municipal yields, do take into account not only the explicit state debt, but also the implicit pension debt, especially since the beginning of the financial crisis.

The coefficients on both explicit and implicit pension debt ratios are statistically significant, economically meaningful and of a roughly comparable order of magnitude, although the coefficient on the explicit debt ratio tends to exceed that on the implicit debt ratio when the latter is calculated using the treasury yield or a fixed discount rate of eight percent. However, the effects of both higher explicit debt and higher implicit debt on municipal yields are essentially concentrated in the crisis period, possibly because the crisis triggered a change in the investors' assessment of the risks associated with a state's indebtedness.

The obvious policy implication of the analysis is that state governments can save resources, hence reduce crowding out of public resources, through lower interest burdens by adequately addressing the underfunding problems of their state pension sectors through reductions in the generosity of the public sector pension arrangements or higher employee and employer contributions. Some states have started doing so indeed.

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