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Fooling the Market?

Municipal Yields and Unfunded State Pension Liabilities

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PRELIMINARY DRAFT - DO NOT CITE OR QUOTE

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Abstract

Existing empirical evidence at the country level exhibits a positive relationship between public indebtedness and the yield on the public debt. Using panel data over the period 2001 - 2014, we show that this relationship holds also for municipal bond yields and the indebtedness of U.S. states. Equally important, we find that municipal bond yields are positively related to implicit state debt, as captured by the financial situation of the states' civil servants pension funds, which are supposed to be guaranteed by the state government. In fact, the yield effect of an extra dollar of unfunded pension liabilities is of a similar magnitude as that of an extra dollar of explicit debt. The interest rate effects of higher explicit and higher implicit debt are mainly concentrated in the period since the start of the crisis.

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

JEL Codes: G12, H74, H75.

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1 Introduction

Both theory and empirical evidence (e.g., Ardagna et al. 2007) suggest that higher public debt levels raise interest rates. However, while the effect of the level of explicit public debt on its its yield has received quite some attention in the literature, the effects on public debt yields of the implicit obligations of governments have been largely overlooked. This is in particular the case for the net pension liabilities of U.S. states towards their civil servants, even though these net liabilities tend to be of a magnitude comparable to the (explicit) public debt (see Figure 1), while they tend to be perceived as "hard"as a state's explicit debt. This implicit state pension debt arises from the defined-benefit character of the pension obligations towards the state civil servants. Over their working life civil servants accumulate pension capital contributions, while at the same time they build up entitlements to future benefits. However, mainly because of a combination of inadequate contributions, overoptimistic economic and financial market projections and unforeseen progress in life expectancy, these entitlements tend to exceed the accumulated capital, thereby resulting in unfunded pension liabilities. In this paper we explore how the funding situation of the state civil servants' pension funds affects the interest rates on municipal debt, while we control for other variables commonly thought to be relevant for debt yields, in particular the state debt. Our sample consists of a panel of all U.S. states over the period 2001 - 2014. The sample period is dictated by the availability of the relevant information on the state pension funds.

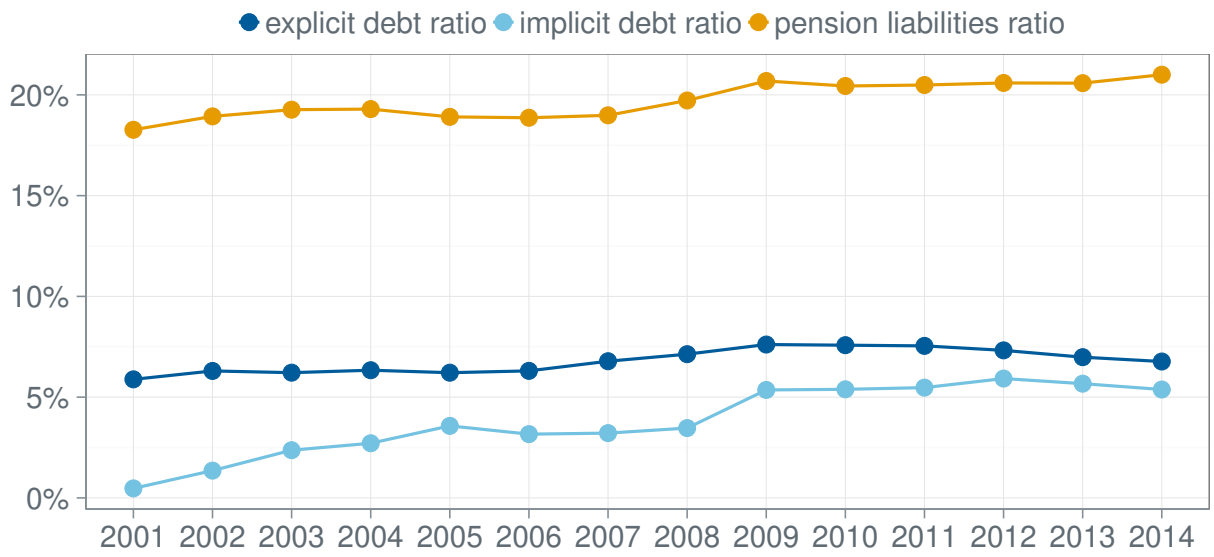
We find that, controlling for the yield on federal debt and the state debt ratio, an increase in the ratio of unfunded pension liabilities or a reduction in the pension funding ratio, i.e. the ratio of pension assets over liabilities, exerts a significant positive effect on the state's municipal bond yield.[1] In fact, we find that the marginal effect of an increase in the implicit pension debt ratio is roughly as large as that of a marginal increase in the explicit debt ratio. The positive effects of both the explicit and the implicit debt on yields are mainly concentrated in the period since the start of the recent economic and financial crisis. We use a large number of tests to confirm the robustness of these findings. However, we find that if we measure the pension funds' financial health with actuarial instead of market values these results weaken. This is primarily due to the fact that actuarial assets are smoothed out over a long period. Our results thus indicate that investors in state debt see through the overoptimistic picture created by the actuarial assessment of the pension funds' financial health and assess the consequences for the state's budgetary sustainability on the basis of pension underfunding measured through market values.

We also investigate the potential presence of non-linearities by allowing for the possibility that investors are more sensitive to changes in the funding situation when a fund is significantly underfunded than when it is well funded. However, we do not find evidence of such non-linearities.

[1] Unless explicitly stated otherwise, a "ratio" refers to a share of state gross product.

Our findings are of potential importance, because recent years have witnessed steadily falling funding ratios of many state pension plans, implying a steady increase in the implicit state debt. Because there is no clear seniority ranking between the explicit and implicit debt - witness the Detroit default case in which a share of both the explicit and the implicit city debt was written off - a continuing increase in the pension debt may eventually cause a crisis in the market for the explicit debt, causing states to be shut off from the capital market.

Figure 1: Median state pension liabilities and state public debt over time



Note: The figure shows the development over time of three debt measures expressed as a percentage of gross state product: the total pension liabilities (pension liabilities ratio), the total unfunded actuarial accrued liabilities that are calculated as a difference between liabilities and actuarial assets (implicit debt ratio) and the explicit state debt (explicit debt ratio). Here dots represent the median values over states in each time period.

The remainder of the paper is organized as follows. Section 2 discusses the relationship with the literature. Section 3 presents the dataset, while Section 4 presents and discusses the results. Finally, Section 5 concludes the paper.

2 Relationship with the literature

This paper connects to several strands in the literature. First, it expands the empirical analyses of the relationship between a government's financial health, as measured by the public debt and deficits, and the yield on its debt. A substantial amount of work exists analyzing this relationship at the country level. For example, using a panel of 16 OECD countries over a number of decades, Ardagna et al. (2007) estimate a positive effect of the primary deficit ratio of GDP on long-term interest rates. Beetsma et al. (2016) confirm their findings. In a panel of 31 advanced and emerging market economies over the period 1980 - 2008 and controlling for a wide range of country-specific factors, Baldacci and Kumar (2010) find that higher public deficits and

public debt raise long-term interest rates. The magnitude of the effects depends among other things 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. For the U.S., Laubach (2009) investigates the relationship between long-horizon forward rates and projections of future federal deficits and debt by the Congressional Budget Office. He finds that this relationship is statistically and economically significant for both deficit and debt projections. However, the literature features less empirical work on the corresponding relationship between public sector financial health and yields on the public debt at the U.S. state level. An early exception is Hastie (1972). Our analysis provides independent supporting evidence for a positive relationship between state debt and state municipal yields, although the focus of our analysis will be on the relationship between the financial health of the state pension sector and municipal yields.

Second, our paper connects to the literature addressing budgetary transparency. Reck and Wilson (2006) investigate how information transparency impacts on the pricing of municipal bonds. They establish that bond prices impound information disclosed throughout the year. However, they find no evidence that prices react to disclosures required by the SEC. Further, according to Ponds et al. (2011), in many countries pension plans impose a financial burden on the government, but the information on this implicit pension debt lacks transparency. Bohn and Inman (1996) find that stricter budgetary restrictions affect the U.S. state finances positively, while they do not find evidence of states pushing deficits into implicit debt positions like pensions.

Third, our paper also relates to work exploring the behavior of pension funds under financial pressure. In particular, Andonov et al. (2016) find that more underfunded pension plans are more susceptible to risk taking.

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

3 Data sources, variables and key figures

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 data we have on the 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.

The data cover over 150 public pension plans in the U.S., which represents 90 percent of all the public funds in terms of both assets and pension 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; a significant majority (around 90%) in terms of assets and liabilities. A priori there is no reason to think that the excluded funds are better or worse funded than the ones in the database, or have any other distinguishing characteristics, except 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.

The historical time series on gross state product (GSP) and state debt we obtain from Chantrill (2015) [2]. We obtain monthly financial data, in particular treasury and municipal bond yields, for each state from Barclays (2015).

3.2 Main variables used in the analysis

The main variables directly obtained from our data sources are:

- YM_{it} = municipal state yield. The Barclays Municipal Bond Index is a rules based, market value weighted index engineered for the long term tax exempt bond market, with average maturity of 14 years,
- YT_{it} = yield on federal treasury debt. Public obligations of the U.S. Treasury with a remaining maturity of one year or more; the average maturity is nine years,
- FR_{it} = the state pension funding ratio. It is the ratio of total actuarial pension assets (aggregated over all funds) over total actuarial liabilities (aggregated over all funds) in each state. The liabilities are the present value of the projected future pension payments,
- IDR_{it} = aggregate unfunded actuarial accrued liabilities, calculated as a difference between actuarial liabilities and actuarial assets, over all pension plans of the state as a ratio of GSP,
- EDR_{it} = (explicit) state debt level as a ratio of GSP.

A potentially important issue is that the financial health of the state pension funds as reflected in the headline figures may not be fully comparable. Pension funds have substantial discretion

[2]This is a resource of data gathered from reports from official government sources. Some data points were randomly checked by authors to confirm data reliability.

regarding their actuarial assumptions and, in particular, regarding the discount rate they can apply to their future benefit payments. The latter is based on the expected return on their assets. However, there exists major disagreement among experts to what extent asset return processes might have changed over time, so that naturally there is leeway regarding the choice of the discount rate for the calculation of the fund's liabilities. In addition, Andonov et al. (2016) find that more poorly funded pension plans are susceptible to increased risk taking, which in turn allows them to increase the rate at which the future benefits are to be discounted, as this rate is based on the expected return on the fund's assets.

The liabilities reported in the PPD are actuarial liabilities. Different plans may apply different discount rates to calculate them. However, applying different rates to discount future benefit payments would only be justifiable if the risks associated with the benefits are different. We have no prior information to assume that this is the case and, for this reason, we recalculate the fund liabilities using a uniform 8% discount rate, which is the median discount rate used by pension plans in most years of our sample.

Novy-Marx and Rauh in their articles (Novy-Marx and Rauh (2009, 2011)) calculate the pension promises using the treasury rates and municipal rates instead of the actuarial discount rate. Brown and Pennacchi (2015) argue that pension cashflows should be discounted at a rate that reflects their riskiness. This yields a better estimate of the present value of pension promises. In most instances this would mean discounting projected benefits against a risk-free yield curve, since pension promises are usually considered to be hard obligations. However, here we stick to a constant and identical discount rate, as we want to compare the pension liabilities across states assuming they are equally risky and we want to avoid our liability measure to depend on the municipal yield, the variable it has to explain.

Concretely, we assume an identical duration for the pension liabilities across the states and given the difference between the actual discount rate and our uniform 8% discount rate,[3] we adjust the liabilities accordingly.[4] This implies that the funds using a discount rate larger than 8% will see an increase in the recalculated liabilities, while those using a lower discount rate will see their recalculated liabilities fall below the reported values. We use a common 8% discount rate, as it is roughly the median discount rate applied by state pension funds. The 8% discount rate is substantially above the risk-free interest rate. However, it is the variation in funding ratios and unfunded liabilities that will be used to explain state debt yields, hence we expect the difference between liabilities discounted at the 8% discount rate and at the risk-free rate to

[3]The data on the discount rate in the PPD database are not complete due to some missing observations for certain years in a number of plans. However, whenever the information is complete, the discount rate is found to be very stable over time for given plans. Hence, we fill in missing values for the discount rate with the observations before or after the years for which records are missing.

[4]Concretely, to impose the same discount rate the pension system liabilities have been recalculated as $LadjD = L(1 - (0.08 - dr)D)$, where L is the actual reported liability, LadjD is the recalculated liability, dr is the actuarial discount rate actually applied by the fund and D is the assumed duration of the fund's liabilities. By duration we refer to the modified duration measure which captures the price sensitivity to interest rates.

mainly end up in the state fixed effects included in our regression specifications.

Unfortunately, we do not have direct information on the duration of the pension funds' liabilities. For our baseline we assume a duration of $D = 15$ years, which is a commonly used estimate for the sensitivity of pension liabilities to interest rates. In our robustness analysis, we also use liabilities recalculated on the basis of durations of 10 and 20 years. We define L as the GASB liabilities reported in the PPD and $Ladj15$ ($Ladj10$, $Ladj20$) as the liabilities recalculated under the assumption $D = 15$ ($D = 10$, $D = 20$) using the uniform discount rate of 8 percent.

The headline figure for the unfunded liabilities is ID (implicit debt), which is defined as the actuarial liabilities minus the actuarial assets reported in PPD. Using our recalculated liability measures as well as the market values of the funds' assets, we can calculate a new measure of the unfunded liabilities. We define $IDm0$ as the actuarial liabilities minus the market value of the fund's assets and $IDm15$ ($IDm10$, $IDm20$) as $Ladj15$ ($Ladj10$, $Ladj20$) minus the market value of the assets. Further, the implicit debt ratio $IDRm15$ ($IDRm10$, $IDRm20$) is constructed as $IDm15$ ($IDm10$, $IDm20$), divided by the gross state product. We also define several measures of the funding ratio: $FRm10$, $FRm15$ and $FRm20$ are the market values of the fund assets divided by the recalculated liabilities $Ladj10$, $Ladj15$ and $Ladj20$, respectively. Figure 2 gives insight into the differences among the funding ratio measures discussed.

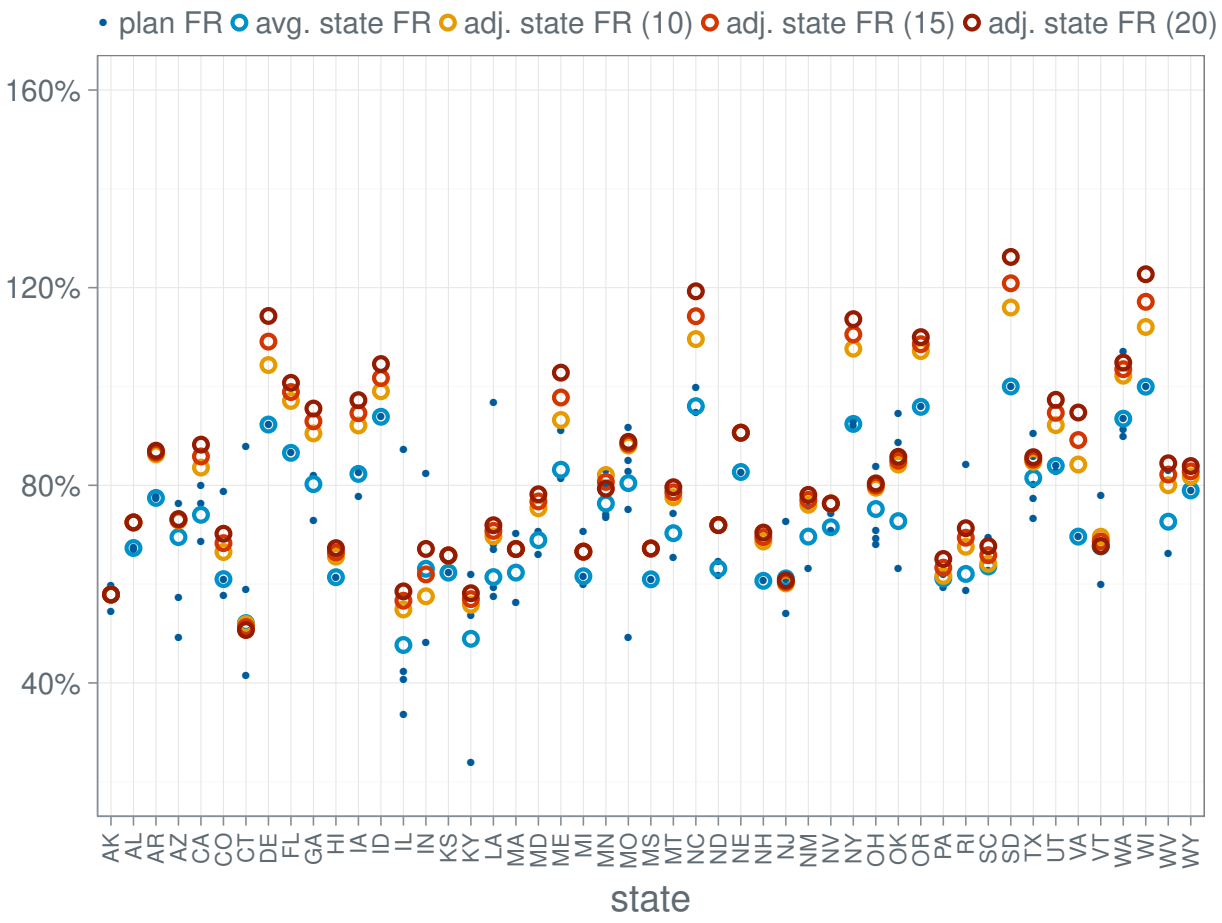
Because many states feature more than one pension fund for the public sector, we add the liabilities of all the funds of a state in the PPD to arrive at a measure for the liabilities at the level of that state. We do the same for our recalculated liability measures as well as the measures for the actuarial and market values of the assets. This way, we obtain state-level measures for the unfunded liabilities, the unfunded liabilities as a share of gross state product and the funding ratio. These state-level measures, rather than measures at the level of the individual pension funds, will be used in the regression analysis.

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.

Figure 3 depicts by state the averages over 2001–2014 of the municipal yields, the debt ratio, the average funding ratio over all state pension funds and the ratio of unfunded actuarial accrued liabilities, respectively. Average municipal yields range from 3.1% to 4.9% across the states, while the average debt ratio reaches a maximum of 18%. This is substantially lower than the public debt ratios of most OECD countries. However, the taxing power at the U.S. state level is a lot weaker than that at the national level of most OECD countries. As far as the financial health of the state pension sector is concerned, we observe that the average reported

Figure 2: Alternative funding ratio measures for the year 2014



Note: The blue dots represent the actual reported funding ratio of each pension plan. The blue circles correspond to the state level funding ratios. The yellow (FRm10), orange (FRm15) and red (FRm20) circles indicate the funding ratio measures calculated as a ratio of market assets to adjusted liabilities with assumed duration of 10, 15 and 20 years, respectively.

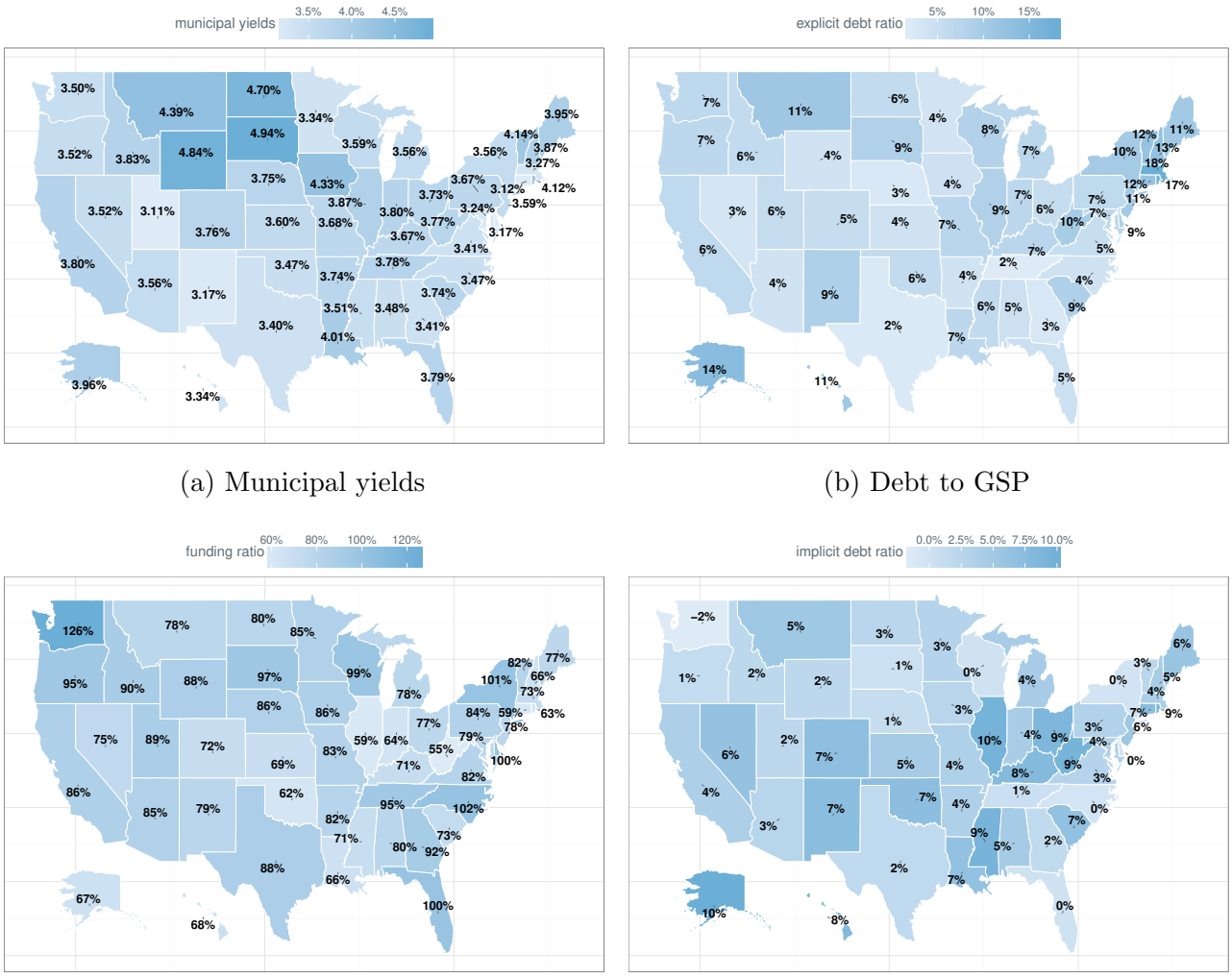
Table 1: Key statistics

Statistic	N	Mean	St. Dev.	Min	Max
municipal yield (YM)	687	0.037	0.008	0.015	0.064
treasury yield (YT)	687	0.030	0.014	0.008	0.052
funding ratio (FR)	687	0.803	0.199	0.423	2.505
implicit debt ratio (IDR)	687	0.044	0.044	−0.075	0.176
explicit debt ratio (EDR)	687	0.074	0.037	0.015	0.204

Note: The statistics are calculated over all observations in the sample.

actuarial funding ratio falls short of 100% in most states, indicating that pension benefits will find it difficult to keep up with increases in cost-of-living adjustments, even if the returns on the invested assets keep up with the rate at which future benefit payments are discounted (in most cases around 8%).

Figure 3: Average values of key variables over the analyzed time period



(a) Municipal yields

(b) Debt to GSP

(c) Funding ratio

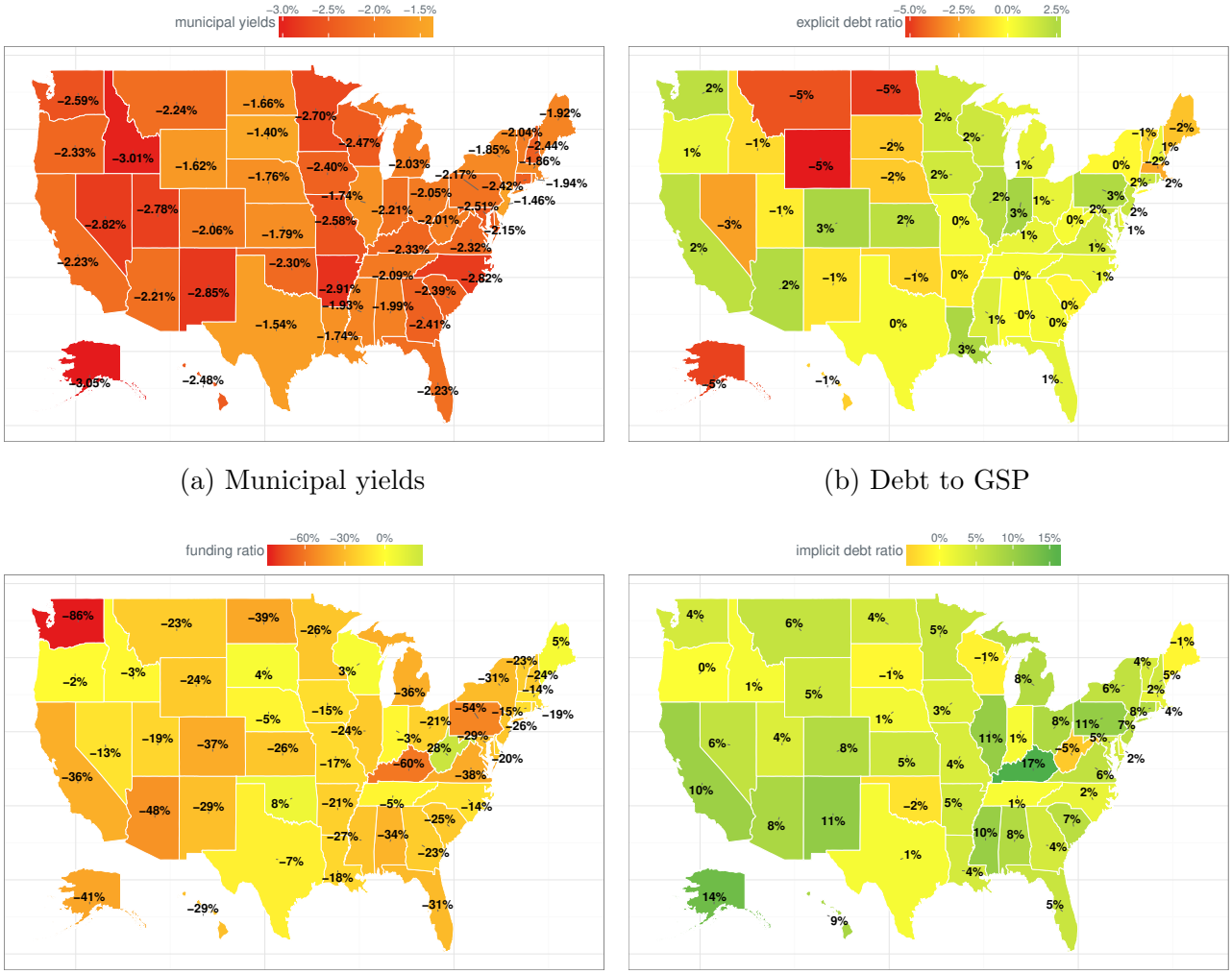
(d) Unfunded pension liabilities to GSP

Note: Darker colored states indicate states with higher values of respective variables. 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 they are available.

Total changes in the key variables between 2001 and 2014 for each state are shown in Figure 4. We observe that annual municipal yields have gone down everywhere, with the largest fall exceeding 3%-points. The pattern regarding the state debt ratios is more mixed, although most states experienced an increase over the sample period. The financial health of the state pension sectors, as measured by the funding ratios, has deteriorated almost uniformly across the states. Only a handful of states saw an improvement of their funding ratios, while all the other states experienced a deterioration. In some instances the funding ratio has deteriorated very substantially. In line with this pattern, unfunded pension liabilities as a share of GSP increased in most states, the maximum being a 17%-points increase in Kentucky. Figure 5 in

Appendix A provides a visual display of all the data observations per state. Again a pattern of falling municipal yields and funding ratios falling over time is visible. Unfunded actuarial accrued liabilities to GSP show a somewhat more mixed picture.

Figure 4: Percentage point changes in key variables during the analyzed time period



(a) Municipal yields

(b) Debt to GSP

(c) Funding ratio

(d) Unfunded pension liabilities to GSP

Note: A yellow shade indicates no change, a red shade indicates a decrease and a green shade indicates an increase in the values of the respective variables. Alaska and Hawaii have been rescaled and moved for a more compact display. For some states 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.

Table 2 reports the correlations between a number of key variables. A number of remarks are warranted. First, not surprisingly, municipal and treasury yields feature a high positive correlation. Second, funding ratios are positively correlated with both municipal and treasury yields, while unfunded liabilities are negatively correlated with both yields. This seems paradoxical. However, this is 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 sector pension funds has shown a downward trend. The trends also explain the relatively high positive correlation between unfunded pension liabilities and state debt as shares of GSP and the relatively strong

negative correlation between the latter variable and the funding ratio. Finally, as expected, the unfunded pension liabilities as a share of GSP and pension funding ratios are highly negatively correlated.

Table 2: Correlation matrix of key variables over all observations

	YM	YT	FR	IDR	EDR
YM	1	0.72	0.17	-0.17	0.02
YT	0.72	1	0.34	-0.32	-0.04
FR	0.17	0.34	1	-0.87	-0.31
IDR	-0.17	-0.32	-0.87	1	0.33
EDR	0.02	-0.04	-0.31	0.33	1

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 ratio of (explicit) debt to GSP. Our main extension of the standard framework is to include measures of the financial health of the civil servants' pension funds in each state. Hence, in its most general format our baseline regression equation reads:

$$YM_{it} = \alpha_i + \beta_1 YT_{it} + \beta_2 EDR_{it} + \beta_3 FRm15_{it} + \beta_4 IDRm15_{it} + \beta_5 CONTROLS_{it} + \epsilon_{it}$$

where we allow for the possibility to include controls as well. 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 rates. We would expect the repayment risk of municipal debt to depend on the ratio of the stock of explicit state debt to GSP 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. 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 benefits. In our regressions we will never include measures of the funding ratio and unfunded liabilities simultaneously as explanatory variables, because the two are highly (negatively) correlated alternative measures of the same thing, namely, the financial health of the pension sector. A priori, we would expect the unfunded liabilities ratio $IDRm15$ to be the

more relevant variable for the municipal yield, because a low funding ratio in a state with a small civil servants' pension sector would in itself carry no repayment threat for the explicit debt. The other advantage of using $IDRm15$ is that it is measured in the same units as the explicit debt ratio EDR. When explicit and implicit debt are considered equally "hard" and market participants are able to calculate $IDRm15$, we expect the coefficients on EDR and $IDRm15$ to be of equal size.

Table 3: Baseline regressions for municipal yields

	Dependent variable:				
	municipal yield (YM)				
	(1)	(2)	(3)	(4)	(5)
treasury yield (YT)	0.426***	0.484***	0.488***	0.488***	0.488***
	(0.017)	(0.022)	(0.018)	(0.018)	(0.019)
explicit debt (EDR)	0.083***	0.068***	0.065**	−0.002	
	(0.021)	(0.022)	(0.026)	(0.032)	
funding ratio (FRm15)		−0.013***			
		(0.004)			
implicit debt (IDRm15)			0.067***		
			(0.011)		
total debt (DR)				0.067***	0.067***
				(0.011)	(0.009)
Model	FE	FE	FE	FE	FE
Observations	687	687	687	687	687
R^2	0.674	0.707	0.712	0.712	0.712
Adjusted R^2	0.623	0.653	0.657	0.657	0.658
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 3 reports the estimates.[5] Column (1) presents the estimates of the most basic regression in which 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. Column (2) shows that, while the explicit debt ratio remains significant at the 1 percent level, the state level funding ratio is highly significant at this level too. The coefficient on the explicit debt ratio is somewhat smaller now, and indicates a 7 basis points rise in the municipal yield for a 1 percentage point increase in the explicit debt ratio. A one percentage point reduction in the funding ratio raises the municipal yield by 1.3 basis points. Hence, even though the funding ratio is a less-than-perfect indicator of the difficulty to repay the explicit debt, it still exerts a statistically and economically significant effect on municipal yields. A potential reason is that the funding ratio is a signal of the degree to which financial discipline by the authorities in a

[5]We report cluster-robust standard errors and within R^2.

state is taken seriously. Column (3) replaces the funding ratio with the implicit pension debt. The explicit debt ratio remains significant (now at the 5 percent level), while the implicit debt ratio is highly significant at the 1 percent level. The point estimate of its coefficient is of almost the same magnitude as that on the explicit debt, and indicates that a one-percentage point increase in the implicit debt ratio raises the municipal yield by 6.7 basis points as opposed to an increase of 6.5 basis points for a one percentage point increase in the explicit debt ratio. The reparametrized regression reported in Column (4), which includes the total debt ratio as the sum of the explicit and implicit debt ratios and the explicit debt ratio together, shows that the coefficients on the explicit and implicit debt ratios are not statistically different.

4.2 Implications of baseline estimates

State policy makers have to make annual decisions regarding the state budget, including financing the state pension funds. If new pension accrual is matched by contributions calculated by discounting the new accrual at a risk free rate, and the assets are invested in a way that matches the liability duration and risk, then there is no mismatch risk between assets and liabilities. Thus there is no implicit pension debt, and the policy makers can concentrate on the budget and its effects on the explicit debt and consequently the yields that translate into the costs of borrowing. Since the pension contributions are in reality calculated on an expected returns basis, tax payers are apparently prepared to accept the mismatch risk, choosing a lower contribution now in exchange for a more volatile contribution in the future, or, in case of inadequate contributions, choosing for a likely underfunded pension system and thus shifting the pension burden to the future generations. The current bad pension funding situation is in part the result of the risk taken in the past by paying lower contributions. This has lead to a sizeable implicit debt which, as shown by the results in the previous section, investor in state public debt are aware of as they require a higher compensation for lending to states with less well-funded civil servant pension plans.

For illustrative purposes, assume no debt is rolled over in period t, so that an increase in the municipal yield is paid only on a net debt increase. In a scenario of rising debt, total debt in year $t+1$ can be expressed as follows:

$$TD_{t+1} = ED_t(1 + YM) + \Delta ED(1 + YM + \Delta YM) + ID_t + \Delta ID, \tag{1}$$

where ΔYM is a function of $(\Delta ED + \Delta ID)$. Whereas in the short term the increased debt yield will only affect the state in the primary debt market, i.e. it will only have to be paid on the newly issued debt, in the longer term the higher yield will be paid on the total debt, given that the implicit debt will have an explicit effect on the budget at some point in the future.

If the state's financial situation is such that the state needs to borrow, the policy makers face the choice of how much of the available resources to allocate to the pension system, since by

paying lower contributions it is possible to substitute implicit for explicit new debt. If policy makers believe that implicit debt is less visible to investors, this might help to explain why pensions have been underfunded in the past. However, our results show that investors see through such trickery, as the effects of an increase in the implicit and the explicit debt on the state debt yields are about the same. Still it might be beneficial for policymakers to substitute implicit for explicit debt, if the redemption of the implicit debt lies further into the future and is in particular due after the current policymakers' tenure has ended.

Based on our analysis, policy makers can expect an increase in borrowing costs of 6.7 basis points for each percentage point increase in the implicit debt to GSP ratio. As an example, given that the pension underfunding aggregated over all states in 2014 is 3.7% of the GSPs aggregated across all states (which is USD 16.9 trillion), the underfunding raises the yield on US state debt by an additional $3.7 \times 0.067\% = 0.25\%$, which would amount to roughly USD 42 bn in extra borrowing costs in 2014 if the additional interest cost were to apply to the full stock of explicit debt. Given that explicit state debt in 2014 is USD 1134 bn, which is 6.7% of the total GSP, a one percentage point increase in implicit pension debt in all states would mean $1134 \times 0.067\% = 0.76$ bn USD in extra borrowing costs in 2014 alone if all debt were rolled over. Acknowledging the expected increase in the state's borrowing costs, policy makers can take this into account when deciding on the budget deficit.

4.3 Robustness

In this subsection we check robustness of the baseline regressions reported above.

4.3.1 Balanced panel

Using the entire sample period implies that we have an unbalanced panel, because for a couple of states information on the state finances is missing for years 2001–2005. Therefore, as a robustness check, we redo the above regressions only for the states for which pension sector information is available over the full sample period (see Table 4). This leaves us with a total of 44 states. Reassuringly, the coefficient estimates of the explicit and implicit debt ratios remain unchanged or virtually unchanged. The point estimate of the implicit debt ratio coefficient is now slightly, though not significantly, smaller than that of explicit debt ratio.

4.3.2 Lags

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 be the

Table 4: Robustness – balanced panel

	Dependent variable:		
	municipal yield (YM)		
	(1)	(2)	(3)
treasury yield (YT)	0.427***	0.482***	0.486***
	(0.018)	(0.022)	(0.020)
explicit debt (EDR)	0.081***	0.068***	0.065**
	(0.023)	(0.024)	(0.028)
funding ratio (FRm15)		−0.012***	
		(0.004)	
implicit debt (IDRm15)			0.062***
			(0.011)
Model	FE	FE	FE
Observations	616	616	616
R^2	0.678	0.709	0.713
Adjusted R^2	0.628	0.655	0.658
Note:			*p<0.1; **p<0.05; ***p<0.01

reporting moment. Reporting moments across pension funds differ. Hence, we repeat our key regressions while taking yields corresponding to the end of the fiscal year plus 1, 2 or 3 months. The results are reported in, respectively, Columns (1) and (2), Columns (3) and (4) and Columns (5) and (6) of Table 5. We observe that the funding ratio and the implicit debt ratio remain significant, although the absolute magnitude of the coefficient estimates 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 is essentially available already at 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 5: Robustness – lagged yields

	Dependent variable:					
	municipal yield (YM)					
	(1)	(2)	(3)	(4)	(5)	(6)
treasury yield (YT)	0.472***	0.476***	0.467***	0.468***	0.462***	0.465***
	(0.021)	(0.018)	(0.020)	(0.019)	(0.018)	(0.018)
explicit debt (EDR)	0.050**	0.048*	0.050**	0.049*	0.068***	0.067***
	(0.023)	(0.027)	(0.023)	(0.025)	(0.020)	(0.021)
funding ratio (FRm15)	−0.010***		−0.009***		−0.004**	
	(0.003)		(0.003)		(0.002)	
implicit debt (IDRm15)		0.053***		0.043***		0.023**
		(0.011)		(0.010)		(0.010)
Model	FE	FE	FE	FE	FE	FE
Observations	687	687	689	689	689	689
R^2	0.669	0.671	0.644	0.644	0.573	0.574
Adjusted R^2	0.617	0.619	0.595	0.595	0.529	0.529
Note:						*p<0.1; **p<0.05; ***p<0.01

4.3.3 Alternative liability estimates

This subsection explores the robustness of our results for different assumptions underlying the recalculation of the liabilities. The standard assumption was a duration of fifteen years and a uniform discount rate of 8%. We first explore the sensitivity to duration assumption, and then to discount rate assumption.

Our alternative durations are 10 or 20 years. Hence, in the above regression we replace $FRm15_{it}$ by $FRm10_{it}$ or $FRm20_{it}$ and $IDRm15_{it}$ by $IDRm10_{it}$ or $IDRm20_{it}$. Thus, overall, we consider a wide range for the duration. If the results remain robust, we can be comfortable with our baseline duration assumption. Table 6 reports the results. We observe that our results are entirely robust with respect to the assumed liability duration.

Table 6: Robustness – liabilities based on alternative durations

	Dependent variable:			
	municipal yield (YM)			
	(1)	(2)	(3)	(4)
treasury yield (YT)	0.487***	0.479***	0.494***	0.482***
	(0.023)	(0.020)	(0.018)	(0.018)
explicit debt (EDR)	0.067***	0.069***	0.064**	0.067***
	(0.023)	(0.022)	(0.026)	(0.025)
funding ratio (FRm10)	−0.013***			
	(0.004)			
funding ratio (FRm20)		−0.013***		
		(0.004)		
implicit debt (IDRm10)			0.068***	
			(0.012)	
implicit debt (IDRm20)				0.065***
				(0.011)
Model	FE	FE	FE	FE
Observations	687	687	687	687
R^2	0.706	0.708	0.710	0.713
Adjusted R^2	0.652	0.654	0.656	0.658
Note:				*p<0.1; **p<0.05; ***p<0.01

Tables 7 and 8 report the results when alternative discount rates are used, a fixed 4% and a treasury yield, respectively. Both tables show very similar results and the effect of implicit debt on municipal yields remains highly significant. However, the effect is now around half of the effect of explicit debt, of which the estimated effect remains essentially unchanged.

Table 7: Robustness – liabilities based on alternative 4% discount rate

	Dependent variable:		
	municipal yield (YM)		
	(1)	(2)	(3)
treasury yield (YT)	0.426***	0.487***	0.471***
	(0.017)	(0.023)	(0.020)
explicit debt (EDR)	0.083***	0.067***	0.064***
	(0.021)	(0.023)	(0.024)
funding ratio (FRm15p4)		−0.021***	
		(0.007)	
implicit debt (IDRm15p4)			0.035***
			(0.008)
Model	FE	FE	FE
Observations	687	687	687
R^2	0.674	0.706	0.693
Adjusted R^2	0.623	0.651	0.640
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 8: Robustness – liabilities based on discounting against the treasury yield

	Dependent variable:		
	municipal yield (YM)		
	(1)	(2)	(3)
treasury yield (YT)	0.426***	0.567***	0.540***
	(0.017)	(0.042)	(0.025)
explicit debt (EDR)	0.083***	0.059**	0.060**
	(0.021)	(0.023)	(0.026)
funding ratio (FRm15YT)		−0.024***	
		(0.007)	
implicit debt (IDRm15YT)			0.030***
			(0.006)
Model	FE	FE	FE
Observations	687	687	687
R^2	0.674	0.722	0.700
Adjusted R^2	0.623	0.667	0.646
Note:			*p<0.1; **p<0.05; ***p<0.01

4.3.4 The treatment of the fiscal years

The state fiscal years never 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 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. The consequence is that for a given year the treasury yields for states with different fiscal year ends are different, while for states with the same fiscal year end they are the same.

However, sixteen plans in our sample have selected the end of the calendar year as their own fiscal year end. In these cases the plans target a different fiscal year end than that of the state. For most states these plans constitute a minority in terms of liabilities, but there are four states in which all plans target end of the calendar year as opposed to the state's official fiscal year end. Table 9 shows the regression outcomes if we select the yields that correspond to the end of the own fiscal year adopted by the majority of the plans in the state.

For simplicity, and because it barely changes the results, from now on we continue to follow the official state's fiscal year end approach.

Table 9: Robustness – yields at the end of own fiscal year adopted by the majority of the plans in a state

	Dependent variable:				
	municipal yield (YM)				
	(1)	(2)	(3)	(4)	(5)
treasury yield (YT)	0.422***	0.485***	0.490***	0.490***	0.489***
	(0.017)	(0.023)	(0.019)	(0.019)	(0.019)
explicit debt (EDR)	0.082***	0.067***	0.065**	−0.005	
	(0.021)	(0.022)	(0.025)	(0.032)	
funding ratio (FRm15)		−0.013***			
		(0.004)			
implicit debt (IDRm15)			0.069***		
			(0.012)		
total debt (DR)				0.069***	0.069***
				(0.012)	(0.009)
Model	FE	FE	FE	FE	FE
Observations	687	687	687	687	687
R^2	0.633	0.668	0.672	0.672	0.672
Adjusted R^2	0.586	0.617	0.620	0.620	0.621
Note:					*p<0.1; **p<0.05; ***p<0.01

4.4 Extensions

In this subsection we extend the baseline model.

4.4.1 Non-linear effects of the pension fund health

One could imagine 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. To investigate whether that is the case, we explore whether the coefficient on the funding ratio or the implicit debt is larger in absolute magnitude when the funding ratio is below 75%, and smaller or zero otherwise. We chose the threshold of 75%, as this is roughly the median funding ratio in our data in recent years. We expand our baseline regression with a variable that interacts a dummy with value one if the funding ratio is below 75% with the funding ratio itself or with the implicit debt ratio. Table 10 shows the results. In both instances the interaction variables are insignificant, while original coefficient estimates are virtually unaffected in terms of magnitude and significance.

Table 10: Non-linearities: interaction with funding ratio dummy

	Dependent variable:	
	municipal yield (YM)	
	(1)	(2)
treasury yield (YT)	0.487***	0.488***
	(0.020)	(0.018)
explicit debt (EDR)	0.069***	0.065**
	(0.022)	(0.026)
funding ratio interaction (FRm15 $\times$ $D^{FRm15<0.75}$)	0.002	
	(0.001)	
funding ratio (FRm15)	−0.012***	
	(0.004)	
implicit debt interaction (IDRm15 $\times$ $D^{FRm15<0.75}$)		0.002
		(0.010)
implicit debt (IDRm15)		0.065***
		(0.014)
Model	FE	FE
Observations	687	687
R^2	0.710	0.712
Adjusted R^2	0.654	0.656
Note:	*p<0.1; **p<0.05; ***p<0.01	

4.4.2 Pension protection and flexibility

Another possibility is that investors might treat states with different levels of pension protection and flexibility differently. In table 11 we explore the interaction between the implicit pension debt and two dummy variables. The pension protection variable is based on Picur and Weiss (2011) and indicates whether the pensions are very strongly protected legally. The pension flexibility variable is based on Munnell et al. (2014) and indicates the extent to which pensions have been adjusted recently. However, neither of these measures seem to have significant effects on the municipal yield.

Table 11: Non-linearities: interaction with indices

	Dependent variable:	
	municipal yield (YM)	
	(1)	(2)
treasury yield (YT)	0.489***	0.489***
	(0.018)	(0.018)
explicit debt (EDR)	0.062**	0.063**
	(0.024)	(0.026)
implicit debt (IDRm15)	0.093***	0.060***
	(0.020)	(0.012)
high pension protection	−0.034	
	(0.023)	
high pension flexibility		0.014
		(0.022)
Model	FE	FE
Observations	687	687
R^2	0.715	0.713
Adjusted R^2	0.658	0.656
Note:	*p<0.1; **p<0.05; ***p<0.01	

4.5 Subperiods

The recent economic and financial crisis that shook developed economies has potentially caused large shifts in economic relationships. In this subsection we split the full sample into two subsamples: the subperiod 2001 – 2007 before the full eruption of the crisis and the subperiod 2008 – 2014 since the start of the crisis. Columns (1), (2) and (3) of Table 12 report the regressions for the period before the crisis, while Columns (4), (5) and (6) report the results for the post-crisis period. The pre-crisis estimates are significant in only one instance and only at the 10 percent level, while the post-crisis estimates are highly significant for both the explicit and the implicit debt. The magnitudes of the point estimates on the explicit debt have

increased substantially in comparison with the full-sample results and have become larger than the coefficient estimate on the implicit debt. The regression reported in Column (6) shows that a one percentage point increase in the explicit debt ratio raises the municipal yield by 15 basis points, while an increase in the implicit debt ratio now raises the municipal yield by 7 basis points. We need to take some care in explaining the observed increases in the coefficient estimates going from the first to the second sub-period, because market values of pension assets are not always available during the first subperiod (this concerns seven observations), in which case we use actuarial assets instead. Nevertheless, we observe the largest increases in the estimated coefficient on the explicit debt ratio, suggesting that investors have become more aware of the dangers of debt increases or have become more risk averse. The relative weakening of the effect of the implicit debt potentially may indicate that investors view pension promises as more easy to renege upon, legally less hard than explicit debt or that they expect that in time effective measures, such as an increase in contributions by the participants, can be taken to limit the pension burden on the public budget.

Table 12: Robustness – before and after the crisis

	Dependent variable:					
	municipal yield (YM)					
	(1)	(2)	(3)	(4)	(5)	(6)
treasury yield (YT)	0.395***	0.400***	0.413***	0.805***	0.819***	0.818***
	(0.020)	(0.020)	(0.021)	(0.023)	(0.023)	(0.024)
explicit debt (EDR)	−0.055	−0.055	−0.054	0.226***	0.150***	0.149***
	(0.037)	(0.037)	(0.036)	(0.034)	(0.027)	(0.029)
funding ratio (FRm15)		−0.001			−0.018***	
		(0.001)			(0.002)	
implicit debt (IDRm15)			0.018*			0.072***
			(0.009)			(0.012)
Model	FE	FE	FE	FE	FE	FE
Observations	338	338	338	349	349	349
R^2	0.641	0.641	0.646	0.809	0.844	0.838
Adjusted R^2	0.542	0.541	0.544	0.688	0.716	0.711
Note:						*p<0.1; **p<0.05; ***p<0.01

4.6 Actuarial reported values

So far we used the market values of assets and adjusted values of liabilities to calculate the funding ratio and unfunded liabilities. Reporting by pension funds themselves and the determination of their policy instruments are based on the actuarial values of both assets and liabilities. The actuarial values of the assets are usually the market values smoothed over several years.

For the full sample period Table 13 reports the regression results if in our measures of the health of the state pension sector we replace the market value of the assets with their actuarial value and/or we replace the recalculated liabilities with their actually reported, actuarial values. Columns (1) and (4) show that only replacing the recalculated liabilities with their actuarial values has virtually no effect on the original results. However, using actuarial values of the assets has a very strong effect: the measures of the financial health of the pension sector lose their significance. If, in addition to using actuarial asset values, we also use the actuarial values for the liabilities, the financial health measures stay insignificant or even gain some significance though with a sign opposite to the original one for the regressions with market values. Table 14 reports the corresponding results for the post-crisis period 2008 – 2014. Now, the funding ratio is always significant with the expected negative sign. As long as market assets are used (Column (4)), the implicit pension debt remains highly significant with a positive sign. The coefficient estimates, including the one on the explicit debt are very close to those under the baseline. Using actuarial assets the coefficient on the implicit debt remains significant, but only at the 5%, and it becomes substantially lower (see Column (5)). Finally, also replacing the adjusted liabilities with their actuarial value in Column (6) lowers the coefficient estimate further. This might indicate that the funding ratio, being easily available and often reported in the media, is still informative when it comes to assessing the risks associated with the state public debt, even though financial market participants tend to rely more strongly on market values.

Table 13: Actuarial versus market values, 2001-2014

	Dependent variable:					
	municipal yield (YM)					
	(1)	(2)	(3)	(4)	(5)	(6)
treasury yield (YT)	0.491***	0.421***	0.407***	0.501***	0.426***	0.410***
	(0.025)	(0.016)	(0.017)	(0.019)	(0.018)	(0.019)
explicit debt (EDR)	0.067***	0.085***	0.089***	0.062**	0.083***	0.088***
	(0.023)	(0.023)	(0.024)	(0.027)	(0.022)	(0.023)
funding ratio (FRm0)	−0.012***					
	(0.004)					
funding ratio (FRa15)		0.001				
		(0.003)				
funding ratio (FRa0)			0.005*			
			(0.002)			
implicit debt (IDRm0)				0.066***		
				(0.012)		
implicit debt (IDRa15)					0.0001	
					(0.011)	
implicit debt (IDRa0)						−0.016
						(0.010)
Model	FE	FE	FE	FE	FE	FE
Observations	687	687	687	687	687	687
R^2	0.702	0.674	0.676	0.705	0.674	0.676
Adjusted R^2	0.648	0.622	0.624	0.651	0.622	0.623
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 14: Actuarial versus market values, 2008-2014

	Dependent variable:					
	municipal yield (YM)					
	(1)	(2)	(3)	(4)	(5)	(6)
treasury yield (YT)	0.844***	0.850***	0.861***	0.845***	0.838***	0.843***
	(0.024)	(0.028)	(0.032)	(0.025)	(0.027)	(0.030)
explicit debt (EDR)	0.152***	0.221***	0.228***	0.153***	0.216***	0.223***
	(0.028)	(0.031)	(0.032)	(0.030)	(0.031)	(0.032)
funding ratio (FRm0)	−0.020***					
	(0.003)					
funding ratio (FRa15)		−0.014***				
		(0.005)				
funding ratio (FRa0)			−0.013**			
			(0.006)			
implicit debt (IDRm0)				0.077***		
				(0.011)		
implicit debt (IDRa15)					0.044**	
					(0.018)	
implicit debt (IDRa0)						0.035**
						(0.018)
Model	FE	FE	FE	FE	FE	FE
Observations	349	349	349	349	349	349
R^2	0.844	0.816	0.813	0.838	0.813	0.811
Adjusted R^2	0.716	0.692	0.690	0.711	0.690	0.688

Note: *p<0.1; **p<0.05; ***p<0.01

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 public debt levels raise yields on the public debt by lowering the borrower's creditworthiness. As a result short-sighted policy makers may be tempted to substitute implicit for explicit debt by paying inadequate pension contributions, as implicit debt might seem less visible. This temptation could be a factor helping to explain the widespread underfunding in the state sector pension system. However, our estimates showed that investors, when pricing the municipal yields, do take into account not only the explicit state debt level, but also the implicit pension debt, especially since the beginning of the financial crisis.

The coefficients of both explicit and implicit debt are statistically significant, economically meaningful and of a comparable order of magnitude. However, the effects of higher debt on yields are primarily concentrated in the post-crisis period, possibly because investors have changed their assessment of the risks associated with the debt or because they have become intrinsically more risk averse. The effect of implicit pension debt on yields weaken when we implicit pension debt is calculated based on actuarial instead of market assets, which suggests that investors see through the veil of pension funds trying to hide the extent of their underfunding.

The obvious policy implication of the analysis is that state governments can overall through reduced interest burdens save resources by adequately addressing the underfunding problems of their state pension sectors by reducing the generosity of their pension arrangements or forcing larger contributions from participants. Some states have started to do so indeed. Others would do well to follow suit. This would not only overall save state resources, but also avoid crowding out other public services by an ever-rising pension provision burden.

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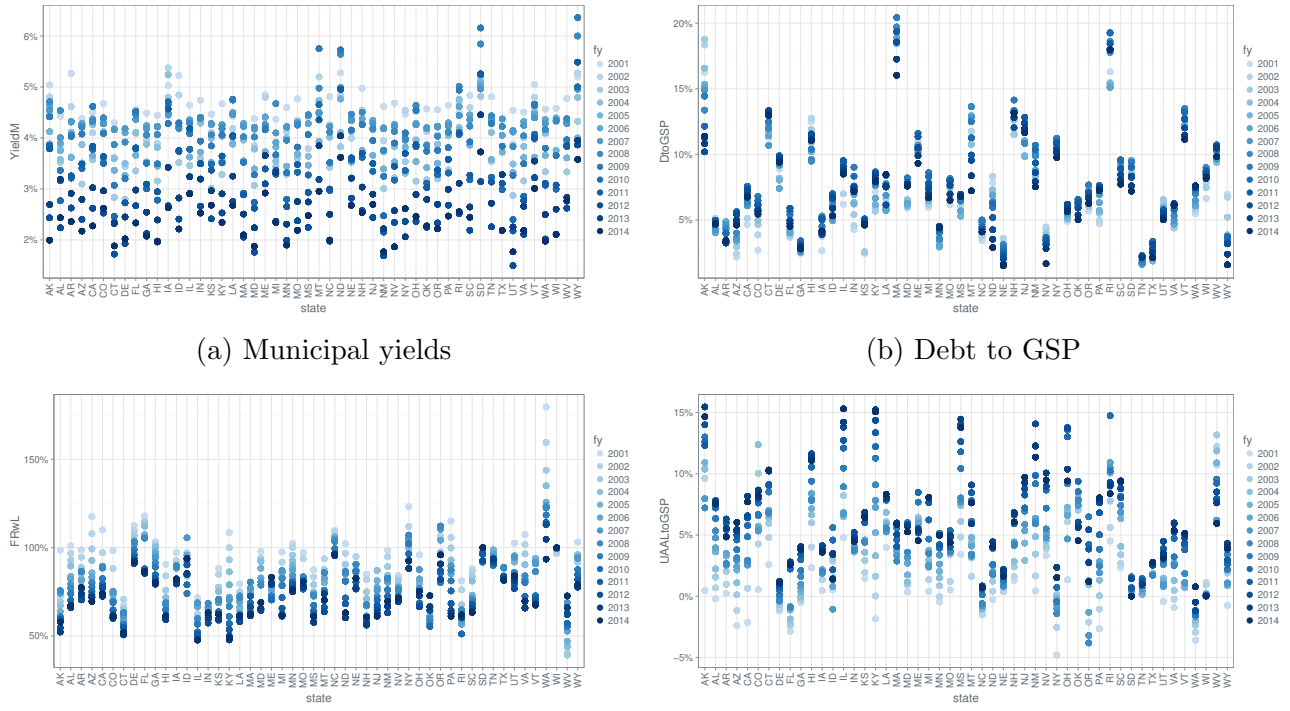
Appendices

A Additional graphs

Figure 5: All observations per state



(a) Municipal yields

(b) Debt to GSP

(c) Funding ratio

(d) Unfunded pension liabilities to GSP

Note: The four panels show the observations during the analysed time period per state for (a) municipal yields, (b) debt to GSP ratio, (c) funding ratio and (d) unfunded actuarial accrued liabilities to GSP ratio. Darker colored dots indicate more recent years.