Do pensions have real teeth? Evidence from the state government borrowing costs

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Abstract

Yes, they do. State governments with risky defined benefit pension plans have higher borrowing costs, as measured by larger bond offering yield spreads. To control for the potential endogenous issue, we utilize the instruments of actuarial firms' reputation, and direct flight between the state capital and actuarial firm headquarter. We further identify the relation between pension plan investment risks and borrowing costs using two quasi-experimental shocks: the introduction of a defined contribution plan or a hybrid plan, and a state political regime shift. The effect of pension investment risk becomes stronger for the states with a large variation of pension contributions and greater financial constraints. These results indicate that pension investment risks trigger subsequent unexpected pension contributions and cash flow shocks for state governments, which are the potential drivers of state borrowing costs. Additional tests show a stronger association between pension fund investment risks and state municipal finance for states with larger union membership and better pension law protection, as well as for general obligation bonds.

JEL classification: G23, G11, H70

Keywords: Pension funds; Funding shortfalls; Investment risks; Municipal bonds

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"An Ohio pension manager risks running out of retirement money. His answer: take more risks."

– The Wall Street Journal, October 20, 2021

1. Introduction

In defined benefit (DB) pension plans, employers promise their employees periodic benefit payments beginning at retirement or other eligibility dates with the payments usually determined based on employees' tenure, age, and salary.[1] These future pension payments represent a liability for employers, as employers (aka, sponsors) are obligated to contribute to and manage pension fund assets to meet their promised future pension benefits. DB plans are widely offered in the public sector. Collectively, these DB pension plans cover pension benefits for about 14.7 million active (working) public employees and 11.2 million retirees and other annuitants as of the fiscal year 2019. With a total of $4.5 trillion in assets under management and an annual benefit distribution of approximately $323 billion,[2] public pension funds are playing a critically important role in assuring Americans achieve financial security when they retire, an essential component of the realization of the "New American Dream" (Stein, 2018).[3]

Despite their massive investment assets, most public pension funds have been struggling to meet their future pension liabilities. One reason is the sharp market downturns in 2000-02 and 2008-09, which have caused a significant loss in pension assets value. Another reason is the increased pension liabilities as a result of a lower interest rate which is benchmarked as a discount rate to estimate the present value of future pension liabilities. By the end of 2018, public pension plans had accumulated a total funding shortfall of $1.24 trillion (measured by the difference between pension fund assets and the present value of future pension liabilities), with an average funding ratio of 71% (the percentage of fund assets over pension liabilities). [4] Such pension fund shortfall would have risen more dramatically following a conservative accounting method suggested by Novy-Markx and Rauh (2009, 2011) to calculate the present value of promised pension benefits.

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[1] In contrast, in defined contribution (DC) pension plans (i.e., 401(k) or 403(b) plans), employers' main responsibility is to make contributions to employees' pension accounts and keep all contributions concurrent while employees manage their own pension account and take all investment risks. DC plans are popular in the private sector while DB plans dominate the public sector, i.e., U.S. states and localities, although in recent years several states have started offering new employees 401(k) or cash balance plans.

[2] These statistics are from Public Pension Data, maintained by the Center of Retirement Research at Boston College. The Public Pension Data displays the statistics on its website based on the data originally from the U.S. Census Bureau (http://www.publicfundsurvey.org/).

[3] See the remarks "*The New American Dream: Retirement Security*", delivered on Oct. 16, 2018 by the U.S. Securities and Exchange Commission (SEC) Commissioner Kara Stein at the Brookings Institution. (https://www.sec.gov/news/speech/speech-stein-101618).

[4] Alternatively, the public DB pension funds in the US are underfunded by 29% relative to a full or 100% funding status. See The State Pension Funding Gap: 2018 by The Pew Center on the States (http: https://www.pewtrusts.org/en/research-and-analysis/issue-briefs/2020/06/the-state-pension-funding-gap-2018).

Novy-Marx and Rauh (2011) estimate that the existing unfunded pension debt would exhaust assets, in aggregate, by the year 2028.[5]

The severe challenges for public pension funds bring up an important question: how will the public pension fund crisis affect the state government budget and operations? We aim to address this question by examining the proliferation of massive unfunded pension liabilities among the states and their implications on state borrowing costs. In particular, we consider both pension fund shortfall or funding ratios, measured by pension fund assets over the present value of future pension liabilities, and the investment risk, measured by the percent of pension fund assets allocated to risky investments, including equity, venture capital, and private equity, on state municipal bond offering yields.

We have three motivations. First, the effect of underfunded government pension plans in the U.S. has touched a large percentage of the population. For example, public employees or retirees are at risk of not receiving pension benefits. Moreover, the taxpayers might be ultimately called upon if the state governments decide to raise the tax to close the funding gap (Mohan and Zhang, 2014). Novy-Marx and Rauh (2009) estimate that each tax-paying household would need to contribute an additional $21,500 to fully fund the pension obligation based on the number of households filing tax returns for 2008.

Second, public pension benefits in most states are backed by legal protection (Monahan, 2010), and thus the shortfalls have to be made up. The increased pension contributions resulting from pension plan underfunding are crowding out other critical government services. Earlier literature shows that poor management in public pension plans could reduce public employment (Erie et al., 2010; Anzia, 2020), discontinue some public services (Erie et al., 2010), default on debt payment (Boyer, 2018), and relocate tax revenue to pension expenses (Fallon, 2020). An even worse effect of public pension plan shortage could even lead to municipal bankruptcy, for example, the Detroit bankruptcy. Due to the COVID-19 pandemic, state and local governments face a significant decrease in tax revenue and severe budget cut, making the pension crisis more severe.

Third, similar to other funds, DB pension plans are subject to investment risk. Anecdotal evidence shows the massive losses in pension funds when the equity market plummeted in both the internet bubble burst and financial crisis periods. Thus, we are motivated to investigate how pension fund investment risk affects state borrowing costs. Our study represents an important extension of previous studies that mainly focus on pension funding shortfall or funding ratios

[5] According to Schuster (2020), Illinois' pension crisis is the nation's worst. Its total pension liabilities increased $7.1 billion to $144.4 billion in the fiscal year 2020, accounting for about 26% of the state's GDP. Pensions will consume 28.5% of the state government budget. The total cost of that debt burden to taxpayers in the fiscal year 2022 will be nearly $11.6 billion, or $1,933 per taxpayer in Illinois based on the number of tax filings in 2019. Measured by pension debt to GDP ratio, Connecticut (22%), Alaska (20%), Kentucky (19%), and New Jersey (18%) are among the worst.

(Boyer, 2018; Novy-Marx and Rauh, 2012; Anzia, 2020). The comparison of two pension funds provided by Merton (2006a) indicates that eyeing the funding ratio might be myopic and causes investors to lose the whole picture of pension fund soundness. Another piece of anecdotal evidence to illustrate the importance of pension investment risk is the 2008 stock market crash, which dramatically reduced pension plan assets value when equity allocations on average account for 56 percent of pension fund assets.[6] The pension funding ratio assesses whether a government has sufficient pension assets to cover its pension liabilities at a certain point in time. Pension fund investment risk, reflecting the extent to which a sponsor's pension assets are sensitive to market fluctuation over time, is a function of the asset allocation choice, interest rate, and market volatility. In this regard, pension funding ratio and investment risk together become a comprehensive reflection of pension fund risk exposure.

So why the municipal bond market? We believe this market provides an important setting to examine the *real* effect of pension risk on public finance. Issuing public debt through the municipal bond market is a main economic resource for state governments to provide public services and fund projects. The municipal bond market is huge and liquid, with over $4 trillion municipal bonds outstanding as of the second quarter of 2019 (Gillers and Banerji, 2019). Several studies have investigated various political, economic, and fiscal factors that affect government borrowing costs, including state budget rules (Poterba and Rueben 2001), corruption and political connections (Butler et al., 2009), state policies for distressed municipalities (Gao et al., 2019a), gubernatorial election (Gao et al., 2019b), and climate change (Painter, 2020). To our best knowledge, we are the first to examine the effect of pension fund financial soundness and investment risk on municipal bond finance. A study closely related to ours is Boyer (2018) who examines how public pension shortfalls affect state default risk, measured by credit default swap (CDS) spreads for municipal bonds; but this study does not consider pension investment risk.[7]

We expect pension funds to have significant effects on a state's borrowing costs. Pension benefits essentially represent an integral component of state governments' liabilities. A large pension shortfall requires governments to divert their valuable funds to make the annual required contributions (ARC) to close the funding gap.[8] The ARC payment reduces funds available to the government and thus affects its ability to borrow at an affordable rate (Aubry et al., 2017). In addition, a higher investment risk of pension funds can result in sizable unexpected ARC and trigger subsequent cash flow shocks. This is because even a moderate fluctuation in the equity market often has a large impact on pension fund value (Merton, 2006a). Uncertainty in ARC and the variation of government funds availability resulting from pension investment risk can further

[6] Mohan and Zhang (2014) report that if the market fell 35 percent (a drop during the 2008 financial crisis), public plans would on average lose 22% of their total fund value.
[7] As not all municipal bonds issued by the state governments have a CDS contract, Boyer (2018) might be subject to a small sample issue as well as a sample selection bias. The study reports that for the full sample of 27 states which have at least one valid CDS contract in the sample from 2015-2016, there is a total of 212 observations.
[8] The ARC, estimated by an actuary at least once every two years, is primarily determined by several factors, including pension plan funding ratios, the assumed rate of return on pension plans, and the age of the workforce, etc.

increase state governments' probability of defaulting on their debt, particularly for those already severely indebted or financially constrained. Moreover, municipal bondholders' wealth can be adversely affected due to the generally favorable treatment of pension liabilities in courts when facing government default on municipal bonds.[9] Therefore, municipal bond investors, including sophisticated institutional investors who can digest pension funding deficit and investment risk may require higher yields to compensate for the increased risks associated with pension plans with deteriorating funding status and higher investment risk.

The above arguments suggest that public pension funds have a significant effect on state government's cost of debt. However, there are several counterarguments. The first one is that there are no explicit, strict regulatory requirements at the federal level mandating state governments to make the ARC or fill out the pension funding gap, even when a pension fund has been severely underfunded.[10] Second, from a legal perspective, a state government will never go bankrupt, as it has unlimited taxing power through which it can ultimately increase its revenue by raising taxes. Therefore, it is unlikely for a state government to default on its municipal bond interest payment.[11] A third reason is that credit ratings, one of the most important determinants of municipal bond yields, may have already captured pension fund status.[12] But they may also put too much emphasis on funding shortfalls when evaluating pension funds, and fail to fully consider pension investment risk (Merton, 2006b, 2007).[13] The above counterarguments indicate that the impact of both pension funding shortfall and investment risk on a state government borrowing costs is an empirical question, which we address in this study in a comprehensive way.

Using a combined sample of state pension funds and municipal bonds from 2001 to 2018, we find that state governments with more risky defined benefit pension plans incur higher borrowing costs, as measured by larger bond offering yield spreads. The effect is economically significant:

[9] Legally speaking, municipal bondholders and pension liabilities have the same priority. But state constitutions may have clauses to protect pension liabilities. According to Fallon (2020), Michigan pension holders are protected by a clause in their state constitution. When Detroit declared bankruptcy, a Federal Court judge put pensioners ahead of bondholders - pensioners received at least 60% of their pensions owed, with no more than 4.5% individual cuts to city retirees. In contrast, Detroit's bondholders (general obligation) received about 41% of their owed obligations.
[10] This is different from private or corporate pension funds which are heavily regulated by the Employee Retirement Income Security Act (ERISA). According to the ERISA, employers' contributions to pension funds are mandatory for the private sector and have priority over the use of cash flows for other corporate activities, including capital investment, mergers and acquisitions, share repurchases, and redemption of debt (Rauh, 2006).
[11] Illinois has the worst pension funding in the US and its governor warns a 20% income tax hike possible if a progressive tax structure proposal does not pass (Bremer, 2020). A 50% increase in the state income tax – taking over $1,800 from a median family's income – would be needed to eliminate the debt (Schuster, 2020). However, with the tax hikes, more residents are leaving Illinois.
[12] For example, according to the Wall Street Journal, Illinois paid a premium to sell $600 million of sales-tax-backed municipal bonds in 2013, after both Fitch Ratings and Moody's downgraded its general credit rating by a notch (Nolan, 2013).
[13] In fact, S&P's Chief Rating Officer acknowledged in an interview that "*It's (pension investment risk) something we'd like to be able to do in the future, but we have not done it to date*" (Chernoff, 2006).

a one standard deviation increase in pension fund investment risk is associated with an increase of 1.898 basis points in bond offering yield spreads, equivalent to an annual overpayment of interest cost of $795,893.73 per bond issuance, representing a significant increase of state borrowing costs. More importantly, such an effect is not fully captured by other drivers of state borrowing costs, as we obtain the above results after controlling for pension funding ratio, bond credit ratings, and a set of control variables.

We provide rigorous tests to mitigate potential endogeneity concerns associated with our results. One source of the identification issue could be reverse causality. In particular, financially constrained state governments are likely to take excessive risky investment assets in their pension funds in the hope of generating more returns to improve their funding status (Mohan and Zhang, 2014). The ultimate, unlimited taxing power possessed by state governments might also incentivize them to take higher investment risks. Another endogenous concern is the omitted unobservable variables that affect the association between pension funding ratio or investment risk and municipal bond yields. Though our main specification controls fixed effects at a month, year, and state level, we might not fully address the endogenous concerns. Thus we use the two-stage least squares (2SLS) with two innovative instrument variables (IV) to further mitigate the endogenous issues. The first IV is a state pension fund actuarial firm's reputation. Actuarial firms are well motivated to protect their reputations as reliable and competent pension evaluators (Myers, 2018). Reputable actuarial firms have the resources and capacity to monitor pension plans more effectively. The other IV is the direct flight between the state capital and the actuarial firm headquarter. The availability of non-stop flights between the state capital and the headquarter of actuarial firms can significantly reduce travel time and expenses for the agent performing the task (Giroud, 2013; Bernstein et al., 2016), thus improving monitoring function, putting state pension plans under more scrutiny. We expect that both IVs are associated with a lower funding ratio and lower pension investment risk. However, there is no a priori expectation that any of the IVs are related to the state borrowing costs. The 2SLS regression results confirm our previous finding that state governments with risky pension funds have larger bond offering yield spreads.

We also identify the relation between pension fund investment risks and municipal bonds financing cost using two quasi-experimental shocks: the introduction of defined contribution (DC) plans or hybrid plans and a state political regime shift. First, several states have introduced new forms of pension plans to their employees in recent years, including DC pension plans (i.e., 401(k)), hybrid plans, or cash balance plans (Goldman and Sterk, 2019). The incentives behind these new plans are to avoid future pension unfunded liabilities and reduce pension contributions (Munnell et al., 2011). Such an overhang relief in pension burden is expected to help state governments reduce cash flow volatility, improve municipal investors' future payoff and decrease bond default risk, resulting in lower borrowing costs. Consistently, we find that compared to those states that have not introduced alternative plans (DC or hybrid), those states with the introduction of these plans, on average, enjoy a reduction of 0.3052 basis points in

borrowing costs. Second, we examine a quasi-experimental shock related to the state political regime shift: the Republican Party regains control of legislation and government offices. (Ansolabehere and Snyder, 2006). The Republican Party has been traditionally viewed as business-friendly by reducing the budget, lowering taxes (Glaeser et al., 2005), and favoring policies and regulations that put business interests ahead of retirement and healthcare benefits (Schieber, 2011; Brandon, 2012) and labor union interests (Olsen, 2021). Due to the favorable market condition when Republican Party wins the election, we expect a weaker relation between the pension fund status and state borrowing costs. We find consistent results that the impact of pension investment risks on state borrowing costs reduces once the Republican Party regains control. That is, compared to the states that have not experienced the regaining control by the Republican Party, those states that the Republican Party regains control witness a reduction of 0.1502 basis points in their borrowing costs. Overall, our tests using IVs and quasi-experimental shocks have provided robust support for our finding that higher pension investment risks are associated with higher state borrowing costs.

We advance our study by investigating the channels through which risky asset allocations in state pension funds influence state borrowing costs. States with more risky assets in their pension funds tend to have volatile pension asset value amid market fluctuations, resulting in a significant variation of pension funding ratios and unexpected ARC. Thus, we conjecture that if the higher risk in pension funds brings greater uncertainty to municipal bonds' interest payment, the positive effect of pension investment risk on municipal bond yields should be stronger for states that are more vulnerable to cash flow uncertainty and face greater financial constraints. We use state government contribution ratio variability (i.e., contribution ratio is measured by the percentage of actual pension contributions made by a state government relative to its annual required contributions or ARC) to measure the state government cash flow uncertainty, and use state-level credit ratings to measure state financial constraints. In the cross-sectional analysis, we find results consistent with our expectations. In particular, the effect of pension investment risk on municipal bond yields is stronger for states with higher volatility of contribution ratios and lower credit ratings. Our results imply that a higher level of investment risk can result in sizable unexpected ARC and trigger subsequent cash flow shocks, which could be a potential channel through which pension investment risks assert a significant effect on state borrowing costs.

We conduct three additional tests to enrich our understanding of the pension effect on state borrowing costs. First, unionized employees generally receive better pension benefits (Freeman, 1983; Munnell and Soto, 2007; Munnell et al., 2011), resulting in higher pension obligations for the state government. Greater unionization for state employees is associated with a larger pension funding shortfall (Mitchell and Smith, 1991) and riskier investment allocation (Mohan and Zhang, 2014). We document an important public union effect on the relation between pension funds and state borrowing costs. Second, in contrast to private DB pension funds that are strictly governed by federal law (i.e., the ERISA) and tax code, public pension funds are mainly subject to state law and pertinent regulations. The legal framework varies significantly across the

50 states regarding the scope of pension benefit protection and the legal basis. We create a Pension Protection Index (PPI) and report a significant effect of the legal pension framework on the relation between pension fund investment risk and state borrowing costs. Both results on the unionization level and the legal protections for public employee pensions are consistent with the different measurement perspectives for pension valuation – a settlement perspective vs. a going concern perspective proposed by Anantharaman and Henderson (2021). Finally, the payoffs of general obligation bonds are fully dependent on state government's fiscal status, while the payoffs of revenue bonds rely more on revenues of the related projects. Therefore, the pension fund's soundness and risks should have a larger impact on general obligation bonds than on revenue bonds. Consistently, we show that the effect of pension investment risk on municipal bond yields becomes stronger for general obligation bonds.

Our study makes several important contributions to the literature. First, we are one of the first to conduct a comprehensive study about the effects of public pension funds on state borrowing costs. To control for the potential endogenous issue, we utilize the instruments of actuarial firms' reputation, and direct flight between the state capital and actuarial firm headquarter. We further identify the relation between pension plan investment risks and borrowing costs using two quasi-experimental shocks: the introduction of defined contribution plans or hybrid plans, and a state political regime shift. We find that pension fund investment risks exert significant effects on municipal bond financing while the effect from funding shortfalls appears to be absorbed by bond credit ratings. Second, by documenting the important effect of pension fund investment risk on state borrowing costs, we provide insights to the state government on managing their cost of debt. The state governments should consider both pension funding ratios and pension fund investment risk when evaluating the financial soundness of pension plans. Our findings also support Merton's (2006a, 2006b, 2007) contention that the biggest pension problem is the investment risk, not the funding shortfall *per se*.

Third, in identifying *how* pension investment risk affects state borrowing costs, we show that a higher level of pension investment risk can result in sizable unexpected ARC and trigger subsequent cash flow shocks, which could be a potential channel through which pension investment risks assert a significant effect on state borrowing costs. Such a channel analysis sheds new light on pension economics, public finance, and pension fund management. Fourth, we report that compared with the impact of credit ratings, the effect of pension investment risks on state borrowing costs is considerably larger. Although investment risks affect credit ratings (Munnell et al., 2011; Boyer 2018), we show that the ratings do not reflect all relevant information on pension plan investment risks. The findings thus suggest that municipal bond investors should look beyond credit ratings and fully assess pension plan status and investment risk.

Finally, this study provides important policy implications. We show that pension fund investment risk is an important issue for policymakers to address when designing policies and

regulations pertinent to pension fund management. Our results suggest that through better managing their pension fund investment risks, state governments can reduce the variability of pension contributions and improve cash flow stability to provide more public services. Given the ongoing pension reforms (i.e., replacing DB pension plans with other types of plans), our results show that the reduction in pension burden can help lower cash flow volatility. Consequently, the pension overhang relief has increased bondholders' future payoff and decreased default risk, resulting in smaller bond yield spreads and lower cost of debt for state governments.

The rest of this paper is organized as follows. Section 2 describes the data and sample, and Section 3 reports empirical results. Section 4 conducts additional tests on the state unionization level, pension legal framework, and general obligation vs. revenue bonds. We conclude the paper in Section 5. The Appendix provides detailed variable definitions.

2. Sample and variables

2.1 Data source and sample

We obtain the U.S. municipal bond data from the Mergent Municipal Bond Securities Database (Mergent). The Mergent database provides detailed information about bond characteristics, including bond yield, issuance size, issuance date, state of issuance, bond types (e.g. indicator variables for whether a bond is senior, general obligation, insured, and tax-exempt, etc.), and bond ratings from credit agencies including Moody, Standard and Poor's, and Fitch's. We restrict our sample to bonds issued between January 2001 and December 2018 with a positive issuance amount and non-missing credit rating information.

We collect the state-sponsored pension fund information from the Public Plans Data (PPD), maintained by the Center for Retirement Research at Boston College.[14] The PPD data includes detailed pension information for 200 plans covering 95 percent of state/local pension plans and participants from the year 2001 to 2020. For a state with more than one pension plan, we estimate the pension asset market value-weighted funding ratio and investment risk. After merging the Mergent database with the PPD data, we construct a final sample containing 152,261 municipal bonds issued by 50 states from 2001 to 2018.[15]

2.2 Key variables

The key dependent variable in our study is a state government borrowing cost, proxied by the municipal bond offering yield spreads (*YIELD_SPREAD*). Offering yield spreads are calculated

[14] The PPD database contains pension information mainly from the state governments' Comprehensive Annual Financial Report (CAFR) and is supplemented by information from the Center for State and Local Government Excellence and the National Association of State Retirement Administrators.
[15] Our municipal bond data stops in 2018 when we start this paper in 2020.

as the yield differences between municipal and Treasury bonds with the same time to maturity. If the time to maturity does not match between municipal and Treasury bonds, we linearly extrapolate the yield-to-maturity using the Treasury bonds with the closest time-to-maturity. We focus on offering yields in the empirical tests because they directly represent the effective interest rates on the bonds at the issuance date and are less subjective to the liquidity that pervades the secondary bond market (Harris and Piwowar, 2006).

The first variable of interest is the pension plan funding ratio (*FUNDING_RATIO*), defined as the actuarial value of pension assets divided by the actuarial value of pension liabilities under the traditional Government Accounting Standards Board (GASB) Standard 25. The actuarial value of pension assets could differ from the market value of pension assets in a given year as the actuarial value of assets is calculated using techniques that smooth out fluctuations of assets that arise from investment gains or losses. The actuarial value of pension liability is equal to the present value of future pension benefits, using a plan's assumed long-term investment return as a discount rate[16]. The second variable of interest is pension fund investment risk (*INVESTMENT_RISK*), defined as the percentage of plan assets allocated to risky asset classes. The PPD Database categorizes pension fund asset allocation into nine asset classes: equity, fixed income, real estate, private equity, hedge funds, commodities, alternative assets, cash, and other investments. Based on the risk level of asset classes, we define pension fund assets as risky investments if the assets are in equity, private equity, and/or hedge funds. For a state with more than one pension, the value-weighted funding ratio and investment risk are used.

2.3 Control variables

At the bond level, an important variable associated with municipal bond offering yields is bond credit ratings (*CREDIT_RATING*). Following earlier studies (i.e., Cantor and Packer, 1997), we transform credit ratings from a letter grade to a numerical value and assign the highest-rated bonds with ratings of AAA or Aaa a value of one, the second highest-rated bonds (AA+ or Aa1) a value of two, the third highest-rated bonds (AA or Aa2) a value of three and so forth. In the case whenever all three ratings (S&P, Moody's, and Fitch) are available, Standard & Poor's rating is used; whenever two ratings of Moody's and Fitch are available, Moody's rating is used. In addition to a numerical scale of credit rating, we create an indicator variable for whether a bond has a credit enhancement arrangement (*CREDIT_ENHANCE*).

Following previous literature on the determinants of municipal bonds offering yields (Butler et al., 2009; Bergstresser et al., 2013), we include a set of control variables that can be classified

[16] Both actuarial pension assets and liabilities are directly reported in the PPD Database. There has been a debate on the appropriate discount rate used to estimate the present value of future pension liabilities. Practitioners, such as actuaries and sponsors prefer to use the expected rate of return of pension assets as the discount rate. Academic researchers, (i.e., Novy-Marx and Rauh, 2009) advocate the use of either Treasury yield or municipal bond yields as the discount rate in estimating public pension liabilities, as this method is consistent with the risk level associated with public pension liabilities.

into two categories: bond characteristics and state-level demographics and economy. In particular, the control variables associated with bond characteristics include: (1) a bond's time to maturity, or the natural logarithm of the number of months until maturity; (2) the natural logarithm of the issuance size of a bond; (3) indicator variables for whether a bond has a call or a put option; (4) indicator variables for whether a bond is insured, senior, sinkable, redeemable or backed by a state government's general obligation; (5) indicator variables for whether a bond is a state or fed tax-exempt; (6) an indicator variable for whether a bond is issued through a competitive bid; (7) the natural logarithm of the number of deals an underwriter has issued over the sample period; and (8) the natural logarithm of the number of bonds that are packaged in one issue.

At the state level, we include the following variables to control for the demographic and economic conditions: (1) natural logarithm of the state population and annual growth rate in population; (2) per capita personal income and the annual employment growth rate; (3) poverty rate; (4) natural logarithm of the median age of a state population; (5) ratio of female population; and (6) education level measured by the ratio of the population with a bachelor degree or above. The Appendix provides variable denotations and detailed definitions.

2.4 Sample statistics

We report the annual distribution of municipal bond issuance in Table 1. Our sample has an average of 8,459 bonds issued in each year from 2001 to 2018. The years 2009 and 2012 have the highest number of bonds (over 10,000), while the year 2001 has the lowest number of bonds (5,196). Overall, Table 1 suggests that bond issuances are not clustered in any year during our sample period.

Panel A of Table 2 presents summary statistics for the state pension plans issued by the 50 states from 2001 to 2018. All continuous variables are winsorized at the 1% and 99% percentile in each year to alleviate the effect of outliers. State pensions have a significant size of assets and liabilities, with an average of $55.60 billion of assets and $71.20 billion of liabilities. The actuarial funding ratio (*FUNDING_RATIO*), defined as the actuarial value of assets over the actuarial accrued liabilities, has an average (median) of 0.80 (0.79), indicating the state pension funds on average are underfunded by 20% relative to a fully funded level.[17] The investment risk in state pension has an average (median) of 0.61 (0.63), suggesting that a state pension plan on average allocates approximately 61% of its assets into risky assets. The standard deviation of the investment risk is 0.11, implying a considerable variation in asset allocation across different pension plans. Figure 1 plots the time series of averaged pension funding ratios and investment risk for the 50 states from 2001 to 2018. Pension funding status has deteriorated dramatically

[17] Different from private DB pension plans, public pension plans with an 80% or above funding ratio are generally considered to be healthy, as ultimately, state governments are being viewed to have unlimited taxing power. That is, by raising taxes, a state government can always make up the unfunded pension liabilities and bring the funding ratio back to 100% or even more.

since 2001 when the tech bubble burst, evidenced by an average funding ratio of 96.73% in 2001 and 73.22% in 2018. However, the investment risk ratio in state pensions shows a steady but slowly increasing trend over time, as it grows from 57.30% in 2001 to 63.13% in 2018. The state pension funds have shown significantly different fund allocations in various asset classes. On average, 50.83% of pension assets is allocated to equity, 25.46% to fixed income, 3.86% to hedge fund, 6.09% to private equity, 6.06% to real estate, 1.55% to alternative assets, 0.07% to other investments, and 0.73% to cash and cash equivalents. Moreover, the fund allocation in risky asset classes varies in state pensions. Notably, the maximum asset allocation is 71.41% to equity, 49.94% to fixed income, 25.86% to hedge fund, and 24.07% to private equity.

We report the top five states with the worst/best funding ratios and the highest/lowest pension investment risk in Panels B and C of Table 2, respectively. The bottom five states with the worst pension funding ratios at the end of 2018 are Connecticut (CT), Kentucky (KY), Illinois (IL), Hawaii (HI), and South Carolina (SC), with a funding ratio from 0.52 to 0.56; while the top five states with the best funding ratios are: Idaho (ID), Washington (WA), Tennessee (TN), Wisconsin (WI), and South Dakota (SD), with a funding ratio from 0.90 to fully funded. Regarding the level of pension fund investment risks, New Mexico (NM), New Hampshire (NH), Kansas (KS), South Dakota (SD), and Louisiana (LA) are five states that allocate the lowest percent of pension assets into risky investments, and Hawaii (HI), Michigan (MI), Arizona (AZ), West Virginia (WV), and Wyoming (WY) are five states that take the highest investment risk in the pension funds. Note that Hawaii is one of the states with the worst funding ratio and the highest investment risk, while South Dakota is one of the states with the best funding ratio and the lowest investment risk.

Table 3 reports summary statistics of bond and state-level variables used in the regression analysis. Panel A presents the descriptive statistics for municipal bonds. The mean (median) for the municipal bond offering yield spreads is -0.004% (0.052%), indicating that on average, state governments pay 0.4 basis points lower in initial offering yields relative to Treasury bonds with the same time to maturity.[18] The average issue size is $172 million with an average maturity of 107.45 months (or 8.95 years). The median credit rating for municipal bonds is 3, indicating half of the municipal bonds in our sample are rated over Aa2 (Moody's) or AA (S&P). Regarding other bond characteristics, 48% of bonds in the sample have a call provision and only 0.3% have a put provision, 20.8% are insured, 87.7% are federally tax-exempt, 95.8% are state tax-exempt, and 5.4% are subject to the alternative minimum tax (AMT).

The municipal bonds could be issued through either competitive or negotiated offerings. The type of offering is an important factor in bond issuance cost. With a competitive offering, multiple underwriters bid for the right of bond issuance, and the winner will offer lower issuance costs to the municipalities. In our sample, 37.4% of bonds are issued using competitive offerings.

[18] Gao et al. (2019b) report the average offering yield spreads during the pre-election period vs. non-election period are -0.616% and -0.701%, respectively based on a sample from 1990 to 2014.

Municipalities also employ underwriters to issue multiple bonds in one package, which shares a similar purpose but differs in characteristics, such as maturity or seniority. Each bond in one package is assigned a separate CUSIP as a unique identifier to trade in the secondary market. The average (median) number of bonds in one package is 24.38 (20).

The state's economic and demographic condition could influence the cost of municipal bonds. As shown in Panel B of Table 3, the states in our sample have an average annual income per capita of $42,192.59, an average population of 6.596 million, an average female population ratio of 5.09%, and an average median age of 37.64. In terms of growth-related variables, the states have an average annual population growth of 0.715%, and employment growth of 0.946%. The average poverty rate in our sample states is 12.357%, meaning that about one in eight Americans may have an annual family income below the poverty threshold.

3. Empirical results

3.1 Baseline results

We construct the following ordinary least square (OLS) regression model to examine the effect of pension funding ratio and investment risk on the municipal bond offering yield spreads, where *i* index states, *j* index municipal bonds, and *t* index month.

$$YIELD\_SPREAD_{i,j,t} = \beta_1 \times FUNDING\_RATIO_{j,t} + \beta_2 \times INVESTMENT\_RISK_{j,t} + \gamma \times X_{i,t} + \theta' \times X_{j,t} + \varepsilon_{i,j,t} \quad (1)$$

We follow earlier literature and include a set of control variables at both bond and state levels that affect the bond offering yield spreads (Butler et al., 2009; Bergstresser et al., 2013). States that are more sensitive to the economic cycle could take more risks in pension funds and issue municipal bonds with a higher cost. Additionally, pension asset allocation and the cost of municipal bonds could simultaneously vary over time. Thus, we include state, year and month fixed effects to control for unobservable time trends and state characteristics. Standard errors are clustered at the state level for the regression analysis.

We report the baseline regression in Table 4. In Model (1), we augment the commonly used municipal bond yields model with the state-level pension fund shortfall, proxy by *FUNDING_RATIO*. In Model (2), we re-estimate the regression equation used in Model (1) by replacing *FUNDING_RATIO* with *INVESTMENT_RISK*, which measures the risky asset allocation in state pension funds. In Model (3), with the inclusion of both *FUNDING_RATIO* and *INVESTMENT_RISK* simultaneously in the regression, we aim to investigate whether the effect of risky asset allocation in state pensions on bond yields exhibited in Model (2) is incremental to the effect of state pension funding shortfall.

Table 4 reveals several important findings. First, the coefficient estimate for *FUNDING_RATIO* is -0.1490 but statistically insignificant (p=0.226) in Model (1), implying that there is no evidence for the significant effect of funding ratio on state borrowing costs. Second, results in Model (2) show that higher investment risk is associated with larger bond yield spreads at issuance, as reported by a positive and significant coefficient for *INVESTMENT_RISK* (β = 0.1977, p-value = 0.026). In terms of economic significance, a one standard deviation increase in pension fund investment risk is associated with an increase of 1.898 basis points in bond offering yield spreads.[19] Given that the average municipal bond issuance size is $172 million, a state government spends $32,645.6 (= 0.01898%×$172 million) more than the Treasury bonds that have the same time to maturity when the pension investment risk increases in one standard deviation. As the average number of bonds in one package is 24.38 (reported in Panel A of Table 3), we estimate that the government's overpayment of interest cost would be $795,893.73 annually per bond issuance. We document a positive association between risky asset allocations in a state pension fund and the municipal bond yield spreads. This is an important finding that has been largely overlooked by previous studies.

We then include the pension funding ratio and the pension investment risk in one regression model. Model (3) shows that the pension funding ratio is statistically insignificant on the bond yield spreads. In contrast, the pension investment risk still has a significant and positive effect on the bond yield spreads (β = 0.1864, p-value= 0.025). The result implies that the pension investment risk has a dominant impact on municipal financing costs compared to the funding ratio or the funding shortfall. Our findings are consistent with the evidence supporting Merton's (2006a, 2006b, 2007) advocacy of the important role of investment risk in pension fund management.

Previous studies show that credit rating is a crucial determinant of municipal bond yields (i.e., Ingram et al., 1983; Capeci, 1991; Hastie, 1972). Consistently, we find positive and significant coefficients for *CREDIT_RATING* across the board. Note that a lower numerical value of *CREIDT_RATING* indicates a better rating. In Model (3), the coefficient for *CREDIT_RATING* is 0.0055 (p-value< 0.001), indicating that with the credit rating downgraded by one notch (e.g., from AA to AA-) the yield spreads will increase by 0.55 basis points. Our key finding in Model (3) is that a one standard deviation increase (or 0.096) in pension fund investment risk is associated with an increase of 1.898 basis points in bond offering yield spreads. Compared with the impact of credit ratings, the effect of pension investment risks on state borrowing costs is considerably larger. The result also suggests that although investment risks affect credit ratings (Munnell et al., 2011; Boyer 2018), the ratings do not reflect all relevant information on pension plan investment risks. Otherwise, credit ratings would be sufficient to explain bond yield

[19] The standard deviation of *INVESTMENT_RISK* is 0.096, as reported in Panel B of Table 3. Thus 0.1977×0.096= 0.01898%, or 1.898 basis points.

spreads.[20] The reason could be due to credit analysts' failure to fully consider pension fund investment risk when analyzing sponsors' credit risk (Merton, 2006b), or due to the stagnant nature of credit ratings. Therefore, the results suggest that municipal bond investors should look beyond credit ratings and fully assess pension status and investment risk.

The signs of coefficients for other control variables are generally consistent with our expectations. Bonds with longer times to maturity have higher yield spreads, reflecting a greater interest risk for the bonds with longer life. Larger bonds and bonds with insurance, put option, federal tax-exempt, redemption, and general obligation offer lower yield spreads as these bond features add value to a stream of fixed income that investors expect to receive. Municipal bonds that are issued through competitive offerings have lower offering yield spreads. Bonds with call option and sink option have higher offering yield spreads. In addition, whether a bond has a credit enhancement arrangement has no significant effect on bond yield spreads. At the state level, bonds issued in states with higher poverty rates have higher yield spreads and those with higher growth rates in employment rates have lower yield spreads. We also include the median age of the state population, education level, per capita personal income, the population, and the rate of change in population but find that they do not have a statistically significant relation with municipal bonds yield spreads. Overall, we show that investment risks have significant effects on state government borrowing costs, after controlling for bond credit ratings and other important factors at the bond and state levels. The effect of pension funding shortfall appears to be subsumed by credit ratings. Moreover, compared with pension funding shortfalls, the investment risk of state pension funds provides more important information content about municipal financing costs, and such information has not been fully captured by municipal bond credit ratings.

3.2 Endogeneity

The prior results indicate that pension investment risk has a significant effect on state government borrowing costs. However, to confirm the validity of the results, it is important to mitigate potential endogeneity, such as reverse causality. Specifically, state governments, subject to financial constraints and budget stringency caused by higher borrowing costs and excessive state expenditure, might be forced to cut back pension contributions, resulting in large pension funding shortfalls. Such funding gaps could impel state governments to take "unnecessary" risky investment strategies for their pension funds in the hope of generating more investment earnings to improve funding status (Mohan and Zhang, 2014). Additionally, the ultimate, unlimited taxing power possessed by state governments might motivate them to take excessive pension

[20] Note that in Model (1), we do not find any significant relation between funding shortfalls and municipal yield spreads. However, when removing credit ratings in Model (1), we find that the coefficient for *FUNDING_RATIO* becomes significant (β = -0.1523, p-value = 0.099), an interesting result that indicates credit ratings might have reflected pension funding status.

investment risk and leave their pension plan underfunded.[21] Another endogeneity concern is that some time-varying omitted unobservable variables or hidden factors can jointly determine the pension funding ratio, the investment risk, and municipal bond yields. In this section, we employ both an IV method and two quasi-experimental shocks to solve the identification issue of our results.

3.2.1 2SLS/IV estimation

Two variables are used as IVs: *Actuarial Firm Reputation* and *Direct Flight*. Actuarial consulting firms provide critical pension fund management-related services to state governments, including estimating the long-term expected return of pension funds and computing contributions required to maintain pension fund solvency. The long-term expected return of pension funds, one of the key parameters for DB pension plans, is used as a discount rate to estimate pension liabilities or the present value of future pension obligations promised by state governments. Actuarial firms could be under pressure from state governments to make optimistic estimations on funding shortfalls. For example, they can impose aggressive assumptions of the long-term expected return of pension funds to lower pension liabilities and inflate pension funding status (e.g., Anantharaman, 2017). However, actuarial firms have strong incentives to uphold their reputations as reliable and competent pension evaluators (Myers, 2018).[22] Such incentives are expected to be stronger for reputational actuarial firms. Reputable actuarial firms can be better shielded from the pressures and monitor pension plans more effectively. We define *Actuarial Firm Reputation* as one if an actuarial firm is on the "Top Audit and Actuarial Firms" by Best's Review, and zero if otherwise.[23]

Previous studies report that travel time reduction lowers the cost of monitoring for firms whose headquarters and their production facilities are geographically separated (Giroud, 2013). Bernstein et al. (2016) find that direct flights increase the interaction between venture capitalists (VCs) and their portfolio companies, leading to more efficient monitoring. Thus, we expect that the availability of direct flight between the state capital and the headquarter of actuarial firms may help the actuarial firms better monitor state-level pension plans. We define *Direct Flight* as

[21] Such a risk-taking incentive can be considered a moral hazard issue, which has been reported to exist for private DB pension funds (Chen et al., 2015). However, the sources of such a moral hazard issue are differences between private and public DB pension funds. As private DB pension benefits are guaranteed by Pension Benefit Guaranty Corporation (PBGC), companies may underfund their pension plans and make risky investments. The PBGC insurance for private DB pension funds is essentially a put option with a striking price equal to the gross value of pension benefit claims (Sharpe,1976; Treynor, 1977), and companies can maximize the put value (and maximize shareholders' wealth accordingly) by investing pension assets in a maximum level of risky assets. In contrast, the moral hazard issue for a public pension fund is mainly from a state government's ultimate, unlimited taxing power.

[22] For instance, Deloitte lists the following actuarial services on its website: Assessment and selection of actuarial assumptions required for measuring pension obligations, benchmarking of actuarial assumptions against the market, gap analysis of the fund's liabilities related to the differences between applied actuarial assumptions and the fund's experience, and actuarial estimation of the fund's assets and liabilities. (https://www2.deloitte.com/ru/en/pages/financial-services/solutions/actuarial-services-for-pension-funds.html)

[23] We recognize the choice of reputational actuarial firms could be associated with state characteristics. When we use the residual values of reputation from the regressions of state variables in the first stage, our conclusion holds.

one if there are non-stop flights between the capital city of a state and the headquarters location of the state pension's actuarial firm, and zero if otherwise.

Based on the discussions above, we expect the two variables: *Actuarial Firm Reputation* and *Direct Flight* to be negatively associated with pension funding status and investment risk but not directly related to state borrowing costs. Panel A of Table 5 presents the 2SLS/IV regression results. In the first stage, the dependent variables are *FUNDING_RATIO* and *INVESTMENT_RISK*, while *Actuarial Firm Reputation* and *Direct Flight* are used as the exogenous predictors. In the second stage, the regression model is the same as our main specification shown in Model (3) of Table 4, except that the fitted values of *FUNDING_RATIO* and *INVESTMENT_RISK* from the first stage are used to replace the original values.

Results from the first stage regressions show that *Actuarial Firm Reputation* and *Direct Flight* are negative and statistically significantly associated with both pension funding ratio (β_1 = -0.0155, *p*-value<0.001; β_2 =-0.0024, *p*-value=0.028) and pension investment risk (β_1 = -0.0057, *p*-value<0.001; β_2 =-0.0065, *p*-value<0.001). The first stage results indicate that actuarial firms with high reputations and non-stop flights to the state capital monitor the pensions more effectively and are significantly associated with lower pension funding ratios and risky asset allocations. In the second stage regression, the coefficient of the fitted value of *INVESTMENT_RISK* is positive and significant (β = 5.1136, *p*-value=0.017) while the coefficient of the fitted value of *FUNDING_RATIO* remains insignificant. The results are consistent with the OLS regression results reported in Table 4.

3.2.2 Introduction of DC or hybrid plans

In recent years, several states, such as Alaska and Michigan, have introduced a DC pension plan (i.e., 401(k)) to their employees, at least to new employees (Goldman and Sterk, 2019). Some states (i.e., Florida) ask their employees to choose between a traditional DB and a newly introduced 401(k) and make the latter a default choice if employees fail to elect. Other states (e.g., Virginia and Indiana) introduce hybrid or cash balance plans, rather than stand-alone DC plans.[24] The changes are mainly driven by a state government's motivation to avoid future pension unfunded liabilities and reduce pension contributions (Munnell et al., 2014). The reduction in pension unfunded liabilities also helps lower the cash flow volatility and the revenue volatility.

We first identify states that have introduced DC plans or hybrid plans in a certain year based on Munnell et al. (2014). To test the potential shock caused by the introduction of a DC or a hybrid pension plan, we define a dummy variable *CHANGE_DC* as one if a state introduces a DC plan or hybrid plan in a certain year or thereafter. For example, Arkansas introduced mandatory DC

[24] With a hybrid plan, public employees have both a DC and a DB retirement plan. For a cash-balance plan, employees have individual retirement accounts that carry a guaranteed rate of return and they do not need to manage investments (Snell, 2012).

for public employees in 2006. Therefore, *CHANGE_DC* equals one for the observations from Arkansas in the year 2006 and after, and zero in the year before 2006. We then interact *CHANGE_DC* with *FUNDING_RATIO* and *INVESTMENT_RISK* to test the effect of such a change on a state government's borrowing costs. Other independent variables are the same as those in previous tables.

Panel B of Table 5 reports the regression results for the effect of pension relief shock on the state borrowing costs. The coefficient of the interaction variable *FUNDING_RATIO*× *CHANGE_DC* is not statistically significant (β= 0.1320, *p*-value=0.320) while the coefficient of *INVESTMENT_RISK*× *CHANGE_DC* is negative and significant at the 1% confidence level (β=-0.4922, *p*-value=0.009). Given the average risky allocation ratio of 0.62 for the sample, the result implies that municipal bond yield spreads on average reduce by 0.3052 basis points (= -0.4922 × 0.62) after a state introduces DC or hybrid pension plans. This effect is economically significant. With an average bond issue size of $172 million, such a reduction indicates a saving of borrowing costs of about $524,944 per year. This evidence is consistent with our prediction that when state governments introduce a mandatory DC or hybrid plan, funding ratio and investment risks have weaker effects on the state government's borrowing costs.

3.2.3 State political regime shift

In this section, we employ another quasi-experimental shock related to state-level politics to mitigate the endogeneity concern: the Republican Party regains control of legislation and government offices. The Republican Party is traditionally viewed as business-friendly as the aggregate stock prices often rise following a Republican victory (Riley and Luksetich, 1980). The Republican governments tend to reduce budget, lower taxes (Glaeser et al., 2005), and favor policies and regulations that put business interests ahead of retirement and healthcare benefits (Schieber, 2011; Brandon, 2012), environmental concerns (Sorkin, 2021), and labor union interests (Olsen, 2021). With the favorable market condition when the Republican wins the election, we expect to observe a lower impact of pension fund investment risks on the municipal bond yield spreads.

We first identify the first year in which the Republican Party gains control of a State. Republican control refers to those state-years in which the Republicans have a majority in the legislative chambers and the governor is a Republican as well (Ansolabehere and Snyder, 2006). We define a dummy variable *CHANGE_REP* as one for the years in which the Republicans regain control of the state, zero if otherwise. We then interact *CHANGE_REP* with *FUNDING_RATIO* and *INVESTMENT_RISK* to test the effect of such a shock on a state government's borrowing costs. Considering the Republican Party is more fiscally conservative and friendly to economic growth, we expect the impact of pension investment risks on state borrowing costs to be lower once the Republican Party regains control. Other independent variables are the same as those used in previous tables.

As shown in Panel C of Table 5, the coefficient of the interaction variable *FUNDING_RATIO*× *CHANGE_REP* is not statistically significant (β=-0.0290, *p*-value=0.827) while the coefficient of *INVESTMENT_RISK*× *CHANGE_REP* is negative and significant at the 5% confidence level (β=-0.2423, *p*-value=0.012). Given the average risky allocation ratio of 0.62 for the sample (reported in Panel B of Table 3), the result implies that municipal bond yield spreads on average reduce by 0.1502 basis points (= -0.2423 × 0.62) in the first year that the Republican Party regains control of a state. With an average bond issue size of $172 million, such a reduction indicates a saving of borrowing costs of about $258,344 annually per issue. This effect is economically significant, providing robust support for our finding that pension investment risks have a significant effect on state borrowing costs.

3.3 Analysis of influence channels

Our results so far have indicated that the investment risks in state pension funds have an important impact on the state government's borrowing cost. We next explore the channels through which risky asset allocations in state pension funds influence municipal bond offering yield spreads. Brown and Wilcox (2009) and Novy-Max and Rauh (2012) claim that the accrued public pension liabilities are at least as senior as state general obligation bonds. The states that invest riskier assets in their pension funds tend to have volatile pension assets in the eyes of market fluctuations, resulting in a large variation of pension funding ratios and consequently, unexpected annual required contributions (ARC) to pension funds. Uncertainty in ARC can trigger subsequent cash flow shocks and increase revenue volatility for a state government, forcing state governments to divert their valuable funds to pension plans and reducing governments' capacity to fulfill their bond obligations. As a result, their borrowing costs are likely to increase to reflect the higher risk associated with the pension fund asset allocation. Following the argument that the higher pension investment risk leads to the greater uncertainty of municipal bond payoff, we conjecture that pension investment risk has a stronger impact on municipal bond costs in states that are more vulnerable to cash flow uncertainty and financial constraints.

3.3.1 ARC variability

We first use the variability of ARC to quantify the extent to which municipal bonds are sensitive to cash flow uncertainty in a state government. As a higher level of investment risk exacerbates the ARC uncertainty, we expect the effect of risky asset allocations on bond offering yields to be stronger for state pension funds with more volatile pension contributions.

We divide our sample into two groups based on the standard deviation of states' pension fund contribution ratio (*ARC_RATIO*), measured as the percentage of actual pension contributions made by a state government relative to its annual required contributions estimated by a pension plan's actuary. We calculate the median of the standard deviation of *ARC_RATIO* for all the pension funds in the sample each year. When a bond is issued by states with a standard deviation

of *ARC_RATIO* less (greater) than the sample median, the bond is classified into the subsample with stable (volatile) pension contributions. We then conduct the subsample analysis using the baseline regression and report the results in Panel A of Table 6.[25] The coefficient for *INVESTMENT_RISK* becomes insignificant for the "stable contribution" subsample (β = 0.1093, *p*-value=0.278) but remains positive and significant for the "volatile contribution" subsample (β = 0.2410, *p*-value=0.010). The results imply that the impact of investment risk on municipal bond yield spread mainly exists in states with pension funds with more volatile cash flows. Moreover, these results indicate that a higher level of investment risk leads to sizable unexpected ARC and triggers subsequent cash flow shocks, which could be a potential channel through which pension investment risks assert a significant effect on state borrowing costs.

3.3.2 State financial constraints

As we conjecture in the earlier session that a higher level of investment risk in pension funds is associated with greater uncertainty of municipal bonds' payoff, we also expect that the high investment risk of pension funds exacerbates the default risk in bonds issued by financially constrained states. Specifically, when a pension fund allocates more to risky investments, it induces greater uncertainty of future cash flows, leading to a higher risk premium to financially constrained states. If so, we expect the effects of investment risk on bond offering yields to be stronger in a subsample of bonds issued by states that are financially constrained.

In this section, we examine the role of state financial constraints on the positive relation between pension fund investment risk and municipal bond offering yields. We use Standard & Poor's (S&P) credit ratings on the state government to measure financial constraints. States with a lower credit rating, on average, have more debt (relative to their GDP) and a tighter financial budget. When allocating riskier assets in pension funds, the financially constrained states face a greater cash flow uncertainty, as they need to divert funds from other uses to make up pension shortfalls, which exacerbates the financial pressure for the governments. We thus expect that the risky asset allocation on pension plans has a stronger impact on municipal bonds issued in states with severe financial conditions. To identify the financially constrained states, we use credit ratings at the state level, and classify the states with a rating worse than AA- or Aa3 as the "constrained states" subsample and other states with a rating better than or equal to AA- or Aa3 as the "non-constrained states" subsample. We use our baseline regression for the subsample analysis. Panel B of Table 6 presents the estimation results. Consistent with our expectations, the coefficient for *INVESTMENT_RISK* is significant at a 5% significance level in the subsample of financially constrained states (β = 0.8556, *p*-value=0.020) but it is weaker (β = 0.1490, *p*-value=0.078) for non-constrained states, confirming our conjecture that the impact of the risky asset allocation of the state pension is stronger for municipal bonds in states with constrained financial conditions.

[25] For brevity, we only tabulate the regression coefficients for *INVESTMENT_RISK* and *FUNDING_RATIO*. The coefficients for other control variables are available from the authors upon request.

Overall, the results in Table 6 shed new light on the channels through which pension investment risk influences municipal bond offering yields by identifying the important role of state governments' cash flow shocks associated with a higher risk level of pension fund investment. A higher investment risk results in a larger variation of pension funding ratios and consequently leads to unexpected pension contributions, triggering subsequent cash flow shocks. Therefore, state governments' borrowing costs are likely to increase to reflect the increased default risk on their municipal bonds.

3.4 Robustness check

We examine the robustness of our main results in this session. We first examine whether our main results are robust to an alternative measure of pension funding ratio. Instead of using the actuarial value of the pension assets and liabilities, we use the market value to measure the funding ratio. The actuarial value of pension assets is often different from the market value in a given year. The actuarial value of assets is calculated using a smoothing method to reduce the fluctuations in pension assets that arise from investment gains and losses. Similarly, the actuarial value of pension liabilities also differs from the market value of pension liabilities. The actuarial value of pension liabilities is estimated by discounting future promised pension benefits with the plan's assumed long-term investment return, while the market value of pension liabilities is estimated by using the plan's blended discount rate, which is a function of assumed long-term investment return and the yields on high-grade municipal bonds issued by the state government. We adopt the market value of pension assets and pension liabilities as an alternative measure of pension fund status with the notice that the mechanical connection between the municipal bond yields and the market value of pension liabilities might induce bias in our results. As reported in Model (1) of Table 7 our main results remain to hold, that is, states with a higher investment risk in their pension funds tend to have higher borrowing costs for their municipal bonds.

Next, we augment the main model by adding additional variables that could simultaneously determine risky asset allocation and bond offering yields: pension contribution ratio and pension funds' past three-year rate of return. In Model (2) of Table 7, the coefficient of *Mkt-INVESTMENT_RISK* continues to be positive and significant (β= 0.1717, *p*-value =0.017), which implies that our results are robust to the inclusion of these additional variables. However, we do not find a significant relation between municipal bond yield spreads and pension contribution ratio, and pension funds' past three-year rate of return.

4. Additional Tests

4.1 State unionization membership

Public employees have the right to form unions and bargain collectively through their union representatives. Unionized employees generally receive better benefits, including generous pensions, early retirement without penalty, and increased cost of living adjustments (Freeman, 1983; Munnell and Soto 2007; Munnell et al., 2011). Increased benefits for unionized employees lead to higher pension obligations for the state government. Previous studies show that greater unionization for state employees is associated with a larger pension funding shortfall (Mitchell and Smith, 1991) and riskier investment allocation (Mohan and Zhang, 2014). For instance, New York City has invested its pension funds into the risky stock market to generate extra income to pay increased pension benefit obligations under the pressure of its unionized employees (Healey et al., 2012).[26] In light of the above discussions, we investigate the effect of employee unionization on the relation between the pension fund and municipal bond yields in this section.

We obtain the percentage of public employees who are union members in each state (*UNION_MEMBER_PCT*) from the Union Membership and Coverage Database, constructed by Barry Hirsch and David Macpherson based on the Current Population Survey (CPS), a monthly household survey (Hirsch and Macpherson 2003).[27] Each state is classified into groups with high/low public employee union membership if its proportion of public employee union membership is above/below the median level of the *UNION_MEMBER_PCT*. We then conduct our baseline regression for each subsample, and report the results in Panel A of Table 8. The coefficient for *INVESTMENT_RISK* remains positive and significant for the high union membership subsample (β = 0.1985, *p*-value=0.045) and is not significant for the low union membership subsample (β = 0.1140, *p*-value=0.549). Interestingly, the coefficient for *FUNDING_RATIO* becomes negative and significant for the low union membership subsample (β = -0.2976, *p*-value=0.031) and is not significant for the high union membership subsample (β = -0.0617, *p*-value=0.726).

The results reported in Panel A of Table 8 suggest that the relation between pension funds and state borrowing costs varies among the states with different levels of unionization membership. One potential explanation is the different measurement perspectives for pension valuation by the states with the different levels of unionization – a settlement perspective vs. a going concern perspective (Anantharaman and Henderson, 2021). From a settlement perspective, pension plan participants are more concerned about their settled pension benefits if the state government were to terminate the plan. Thus settlement perspective has short-term nature. In contrast, from a going concern perspective, participants focus more on the asset allocation of pension funds and the expected returns in the future, and such a perspective is a long-term perspective in nature. Highly unionized public employees have more bargaining power, and their pension benefits are usually better and more secure (Freeman, 1983; Munnell and Soto 2007; Munnell et al., 2011).

[26] As another example, California Governor Arnold Schwarzenegger proposed to change the pension system so that new employees would be covered by a 401(k)-style plan. However, the California State Employees Association successfully campaigned against the proposal (Byrnes. 2005).
[27] The data are available at http://www.unionstats.com

Therefore, the going concern perspective should be more relevant to them. That is, the long-term investment risk of a pension fund becomes a more important factor when evaluating the relation between pension funds and state borrowing costs. However, those public employees with a lower level of union membership are more concerned about the termination of their pension funds and the pension benefit amount they expect to receive upon the plan termination. As such, pension funding status, or whether pension assets are sufficient to meet pension liabilities, becomes a more relevant factor.

4.2 Does law matter?

State governments serve as pension plan sponsors, and pension plans cannot be managed in a vacuum – they are primarily subject to state law and legislative structure pertinent to public employee pensions. Legal protections for employee retirement benefits vary dramatically at the state level regarding legal basis and protection scope. In particular, legal basis, or the sources of legal protections for pensions include (1) State Constitution, (2) Common-law contractual and State statute, (3) Common-law contractual, (4) State statute, and (5) other bases, including the gratuity approach, promissory estoppel, and property interest (Monahan, 2010; Goldman and Sterk, 2019; The PEW Report, 2019). State Constitutions provide the most explicit and extensive protection to state pension plans.[28]

So what is protected? The scope of protection can vary significantly even among states with the same source of legal protection for pension benefits (Monahan, 2010; The PEW Report, 2019). The protection coverage could include past, future, or both past and future pension benefits. But some states are unclear on whether protection applies to future accruals, while other states have no detailed protection (Monahan, 2010).

State laws and institutions that promote a higher level of transparency with government liability and put greater constraints on legislative control over funding contributions are associated with a better funding status (Shnitser, 2015). Consistently, state constitutional mandates of pension obligations are strongly correlated with adequate pension funding (Goldman and Sterk, 2019). Considering the important impact of a legal framework and institutional design at the state level on public pension funds, we investigate the effect of the legislative framework on the relation between pension funds and state borrowing costs in this section.

[28] According to Monahan (2010), the gratuity approach to public pensions holds that the pensions are gratuities to public employees and a state can amend or modify pensions at any time without the agreement of its employees. In contrast, the common-law contractual approach embraces pensions as a contract between a state and its participants. Such a contract can be specified by a constitutional provision or inferred by a court. With a promissory estoppel approach, some states (i.e., Minnesota), instead of considering pensions as a formal contract, view pensions as a promise that is legally binding as such a promise, if otherwise not honored, may cause injustice for promisees. According to the property interest approach, pensions should be protected to the extent that public employees' rights in pension claims can be considered property.

We first create an innovative Pension Protection Index (PPI) to quantify the strength of public pension benefit protection for 50 states in the U.S. based on the legal framework provided by Monahan (2010) and The PEW Report (2019). We calculate the PPI as the production of two aspects of pension benefit protection: the legal basis and the scope of the protection. In particular, a legal basis value is assigned 5 when the source of the legal protection is the State Constitution, 4 when the source of the legal protection is both Common-law contractual and State statute, 3 when the source of the legal protection is Common-law contractual, 2 when the source of the legal protection is a State statute, and 1 for other types of sources. A protection scope value is assigned 3 when both past and future accruals are protected, 2 when past accrual is protected and future accrual protection is possible, 1 when only past accrual is protected, and 0 for neither past nor future accrual is protected. The index value ranges from 15 to 0, with Alaska, Illinois, and New York at the top (index value 15) and Indiana and Texas at the bottom (index value 0). We then assign each state to groups with high/low levels of law protection of pension benefits if the state with the index is higher than the median level of the sample. We then conduct our baseline regression in each group and report the results in Panel B of Table 8. We then conduct our baseline regression for each group, respectively, and report the results in Panel B of Table 8. The coefficient for *INVESTMENT_RISK* remains positive and significant for the high law protection group (β = 0.2133, *p*-value=0.050) and is not significant for the low protection group (β = 0.0290, *p*-value=0.828). Consistent with our previous findings, the coefficients for *FUNDING_RATIO* are not significant for both high and low protection subsamples.

4.3 General obligation vs. revenue bonds

Municipal bonds can generally be classified into two types: general obligation (GO) bonds and revenue bonds. General obligation bonds are backed by the general tax revenue of a state government, while revenue bonds are supported by a specific revenue source, such as fees collected from a toll road or a parking garage. Therefore, the pension fund's soundness and risks should have a larger impact on general obligation bonds than on revenue bonds. The above risk framework analysis suggests that the effect of pension investment risk on municipal bond yields should become stronger for general obligation bonds.

The result reported in Panel C of Table 8 confirms the above conjecture. After dividing the whole sample into two groups: a group of general obligation bonds and a group of revenue bonds and conducting the baseline regression for each subsample, respectively, we find that the coefficient for *INVESTMENT_RISK* remains positive and significant for the general obligation bonds subsample (β = 0.1596, *p*-value=0.057) and is not significant for the revenue bonds subsample (β = 0.1488, *p*-value=0.402).

5. Conclusions

The issue of state borrowing costs is central to public finance decisions. In the eyes of the deteriorating status of public pension funds in the U.S., we examine whether pension fund shortfall and its investment risk affect the state government's cost of debt. We document that the pension investment risk has a significant effect on municipal bond yields after controlling funding status, bond ratings, and other bond/state-level characteristics. To mitigate the potential endogenous issue, we adopt the 2SLS regression with two novel instruments of actuarial firms' reputation and direct flight between the state capital and actuarial firm headquarter. We further identify the relation between pension investment risks and borrowing costs using two quasi-experimental shocks: the introduction of defined contribution or hybrid plans and the state political regime shock. We provide strong evidence to support Merton's (2006a, 2006b, 2007) contention that the biggest pension problem is pension investment risk, not the funding shortfall. Our results also suggest that state governments and municipal bond investors should consider both funding shortfall and investment risk when evaluating pension plans.

We conduct a cross-sectional regression analysis to explore how pension investment risk affects state governments' borrowing costs. We show that the effect of risky asset allocations on bond yields becomes stronger for states with more volatile pension contributions and greater financial constraints. Our results shed new light on the channels through which pension investment risk influences municipal bond offering yield spreads. A higher investment risk results in a larger variation of pension funding ratios, leading to unexpected pension contributions, which further trigger subsequent cash flow shocks. As a result, state governments' borrowing costs are likely to increase to reflect the increased default risk on their municipal bonds.

We further our analysis by considering a state unionization level and legal protection for pension benefits. Our result indicates that public unionization plays a significant role in the relation between pension funds and state borrowing costs. In addition, we show that the effect of pension investment risk on governments' borrowing costs varies for states with different legal frameworks. To investigate why the impact of pension investment risk varies in states with different levels of unionization for pension benefits, we propose two measurement perspectives for pension valuation– a settlement perspective vs. a going concern perspective (Anantharaman and Henderson, 2021).

Defined benefit pension plans represent a significant component of state governments' financial statements and currently face severe challenges. This study sheds new light on how pension risk overhang affects state governments' borrowing costs. The documented results provide valuable information for a state government to manage its cost of borrowing and for investors to better assess the bond value when a state government issues bonds with more risky pension funds. Finally, our findings have important policy implications, which suggest that besides pension funding shortfalls, pension investment risk is an important factor for policymakers to consider when designing new laws and rules to ensure the soundness of the U.S. public pension system.

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Appendix A: Variable Definitions

YIELD_SPREAD	Municipal bond offering yield spreads (reported in percentage), or the difference between the offering yield of a muni bond and its corresponding Treasury bond yield. The corresponding Treasury bond is the Treasury bond with the same time to maturity as the muni bond on its issuance date. If time to maturity does not match between municipal and Treasury bonds, we linearly extrapolate Treasury yields.
FUNDING_RATIO	Funding ratio of the state pension fund is based on actuarial value and measured under traditional GASB 25 standards. The (GASB 25) funding ratio is equal to the actuarial value of assets divided by the actuarial value of the liability. For a state with more than one pension, the value-weighted funding ratio is used. The actuarial value of the assets is measured under the traditional GASB 25 Standard. The actuarial value of the assets often differs from the market assets in a given year because the actuarial value of the assets is calculated using techniques that smooth out fluctuations in the level of assets that arise from investment gains and losses. The actuarial value of the liabilities is measured under traditional GASB 25 standards. The actuarial value of the liability is equal to the present value of future benefits, discounted using the plan's assumed long-term investment return. Liabilities are measured under GASB 67 standards. The total pension liability is equal to the present value of future benefits, discounted using the plan's blended discount rate.
INVESTMENT_RISK	The ratio of risky assets (equity, venture capital, and private equity) over total assets of the state pension. For a state with more than one pension, the value-weighted ratio is used.
MATURITY	Natural log of the bond's maturity in the number of months (not considering options of the issue).
AMOUNT (NATURAL LOG)	Natural log of the amount of the issue in million dollars.
AMOUNT (mil.)	The amount of the issue in million dollars.
CREDIT RATE	A numerical scale of credit rating. The highest-rated bonds (AAA or Aaa) are given a value of one, bonds with ratings of AA+ or Aa1 are given a value of two, and so forth. In the case where all of the three ratings (S&P, Moody's, and Fitch) are available,

	Standard & Poor's rating is used; where two ratings (Moody's and Fitch) are available, Moody's rating is used.
CREDIT ENHANCEMENT	A dummy variable for municipal bonds with a credit enhancement arrangement.
PUT DUMMY	A dummy variable equal to one if the bond is puttable.
CALL DUMMY	A dummy variable equal to one if the bond is callable.
INSURANCE	A dummy variable equal to one if the bond is insured.
SENIORITY	A dummy variable equal to one if the bond is senior.
STATE TAX EXEMPT	A dummy variable identifying whether the bond is exempt from state taxes.
FED TAX EXEMPT	A dummy variable identifying whether the bond is exempt from federal taxes.
AMT DUMMY	A dummy variable for bonds that are subject to the alternative minimum tax.
REDEMPTION DUMMY	A dummy variable equal to one if the bond has redemption arrangement.
SINK DUMMY	A dummy variable equal to one if the bond is sinkable.
GENERAL OBLIGATION	A dummy variable equal to one if the bond is general obligation backed.
COMPETITIVE ISSUE	A dummy variable equal to one if the bond is competitively issued.
UNDERWRITING EXPERIENCE	Natural log of the number of deals an underwriter has issued in the sample period (2001-2018)
NUMBER OF CUSIPS IN THE ISSUE (NATURAL LOG)	Natural log of the number of bonds that are packaged in each issue.
MEDIAN AGE	Natural log of the median age in the state.
FEMALE POPULATION RATIO	Ratio of the female population over total population in the state year (in decimals)
BACHELOR POPULATION PROPORTION	Ratio of people with a bachelor degree or above over total adult population in the state year (in decimals).
PER CAPITA PERSONAL INCOME	Natural log of per capita personal income in the state year (in $1,000).
POPULATION	Natural log of the state population in a year (in Millions).

% CHANGE IN POPULATION	Change of total population from prior year to current year for a state (in percentage).
% POVERTY RATE	Poverty rate for a state year (in percentage), or the percentage of population that have annual family resources below the poverty threshold.
% CHANGE EMPLOYMENT	Change of employment rate from prior year to current year for a state (in percentage).
ACTUARIAL FIRM REPUTATION	Equal to one if an actuarial firm is on the "Top Audit and Actuarial Firms" by Best's Review, zero if otherwise.
DIRECT FLIGHT	Equal to one if there are non-stop flights between the capital city of a state and the headquarter location of the state pension's actuarial firm, zero if otherwise.
CHANGE_DC	A dummy variable used to test the potential shock caused by the introduction of a DC or a hybrid pension plan. It has a value of one if a state introduces a DC plan or hybrid plan in a certain year or thereafter.
CHANGE_REP	A dummy variable used to test the potential shock caused by the state political regime. It has a value of one for the first year in which the Republicans regain control of the state, zero if otherwise. Republican control refers to those state-years in which the Republicans have a majority in both legislative chambers and the governor is a Republican as well (Ansolabehere and Snyder, 2006).

Figure 1: Evolvement of average pension funding ratio and investment risk from 2001 to 2018

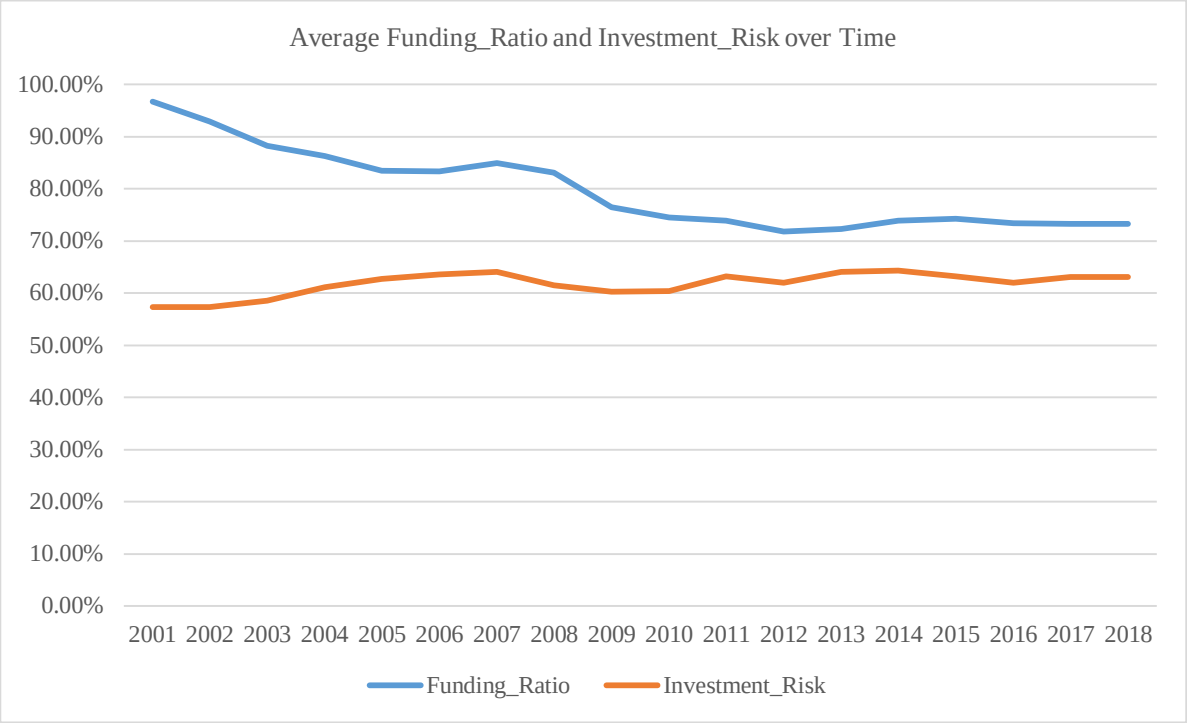

Table 1: State-level agency issued municipal bonds offering distribution by year

The table shows the annual distribution of the municipal bond issuance from 2001 to 2018. We obtain the U.S. municipal bond information from the Mergent Municipal Bond Securities database. We restrict our sample to the bonds issued between the year 2001 and 2018 with a positive issuance amount and non-missing credit rating information.

Year	Number	Percentage
2001	5,196	3.41
2002	7,296	4.79
2003	8,192	5.38
2004	8,194	5.38
2005	9,617	6.32
2006	8,403	5.52
2007	8,515	5.59
2008	7,787	5.11
2009	10,423	6.85
2010	9,953	6.54
2011	8,329	5.47
2012	10,419	6.84
2013	8,127	5.34
2014	7,808	5.13
2015	9,050	5.94
2016	9,471	6.22
2017	9,067	5.95
2018	6,414	4.21
Average	8,459	5.56
Total	152,261	100

Table 2: Information for state pension features

This table provides information for state pension features for 50 states in the USA from 2001 to 2018. Panel A is for the descriptive statistics for state pension features including actuarial funded ratio, risky allocation ratio, actuarial asset size, actuarial liability size, and proportion of asset allocation to equity, fixed income, hedge fund, private equity, real estate, commodities, alternative assets, others, and cash. The number of observations is 900. Panel B provides information for the five states with the highest and lowest actual funded pensions at the end of 2018. Panel C provides information for the five states with the highest and lowest risky allocated pensions at the end of 2018.

Panel A: State pension fund features

	Mean	S.D.	Min	P25	Median	P75	Max
FUNDING_RATIO	0.80	0.16	0.35	0.68	0.79	0.90	1.67
INVESTMENT_RISK	0.61	0.11	0.08	0.58	0.63	0.66	0.76
ACTUARIAL_ASSETS	55,604,421	94,355,371	246,614	10,945,800	2,7631,999	57,756,836	800,326,998
ACTUARIAL _LIAB	71,199,418	119,650,204	254,767	14,467,894	36,648,204	72,251,539	1,113,169,761
EQUITY	50.83%	11.45%	0.27%	46.00%	52.83%	58.00%	71.41%
FIXED_INCOME	25.46%	7.20%	0.11%	20.32%	25.00%	30.00%	49.94%
HEDGE_FUND	3.86%	5.54%	0.00%	0.00%	0.42%	5.85%	25.86%
PRIVATE_EQUITY	6.09%	5.11%	0.00%	0.91%	5.83%	9.45%	24.07%
REAL_ESTATE	6.06%	4.09%	0.00%	2.83%	6.66%	9.07%	17.74%
COMMODITIES	1.55%	2.89%	0.00%	0.00%	0.00%	1.85%	15.00%
ALTERNATIVE_ASSETS	1.44%	4.04%	0.00%	0.00%	0.00%	0.00%	24.80%
OTHER_INVESTMENTS	0.07%	0.56%	0.00%	0.00%	0.00%	0.00%	8.61%
CASH	0.73%	1.21%	0.00%	0.00%	0.05%	0.99%	9.99%

Panel B: Five states with the healthiest and worst pension plans at the end of 2018

State	Funding Ratio	Actuarial Assets	Actuarial Liabilities
Five States with the lowest funding ratio			
CT	0.52	34,802,317	70,423,832
KY	0.53	32,151,977	69,586,713
IL	0.54	158,209,538	335,807,903
HI	0.55	16,512,700	29,917,400
SC	0.56	31,685,130	56,482,847
Five States with the highest funding ratio			
ID	0.90	16,274,800	17,991,200
WA	0.93	69,697,200	75,484,800
TN	0.94	50,733,305	53,751,837
WI	0.99	108,361,410	110,116,264
SD	1.00	12,721,001	12,711,930

Panel C: Five states with the riskiest and safest pension plans at the end of 2018

State	Investment Risk	Equity%	Hedge Fund%	Private Equity%
Five States with the lowest investment risk				
NM	49.38%	30.45%	9.05%	9.88%
NH	50.05%	49.82%	0.14%	0.09%
KS	50.58%	48.46%	0.00%	2.12%
SD	54.40%	54.40%	0.00%	0.00%
LA	54.55%	49.59%	2.90%	2.06%
Five States with the highest investment risk				
HI	71.92%	56.00%	5.00%	10.92%
MI	72.29%	45.10%	14.97%	12.22%
AZ	73.78%	46.44%	9.57%	17.77%
WV	75.94%	54.92%	9.99%	11.03%
WY	81.40%	42.50%	19.00%	19.90%

Table 3: Summary statistics of main variables used in the regression analysis

This table provides summary statistics for the variables in our sample. The sample covers municipal bonds with a maturity of 3 months to 30 years and was issued by state-level governmental agencies from 2001 to 2018. The number of observations is 152,261.

Panel A. Bond level variable

Variable	Mean	S.D.	P5	P25	Median	P75	P95
YIELD_SPREAD (%)	-0.004	0.698	-0.971	-0.576	-0.052	0.456	1.243
MATURITY	4.677	0.727	3.219	4.317	4.796	5.198	5.583
AMOUNT (NATURAL LOG)	17.990	1.438	15.528	17.034	18.002	19.050	20.211
AMOUNT (mil.)	172.000	391.247	5.585	25.000	65.920	188.000	599.000
CREDIT RATE	7.649	8.126	1	2	3	21	21
CREDIT ENHANCEMENT	0.050	0.218	0	0	0	0	0
PUT DUMMY	0.003	0.058	0	0	0	0	0
CALL DUMMY	0.480	0.500	0	0	0	1	1
INSURANCE	0.208	0.406	0	0	0	0	1
SENIORITY	0.003	0.058	0	0	0	0	0
STATE TAX EXEMPT	0.958	0.2	1	1	1	1	1
FED TAX EXEMPT	0.877	0.329	0	1	1	1	1
AMT DUMMY	0.054	0.227	0	0	0	0	1
REDEMPTION DUMMY	0.212	0.408	0	0	0	0	1
SINK DUMMY	0.081	0.272	0	0	0	0	1
GENERAL OBLIGATION	0.483	0.500	0	0	0	1	1
COMPETITIVE ISSUE	0.374	0.484	0	0	0	1	1
UNDERWRITING EXPERIENCE	7.695	1.255	5.043	7.171	7.961	8.555	9.336
NUMBER OF CUSIPS IN THE ISSUE (NATURAL LOG)	2.989	0.655	1.946	2.708	2.996	3.296	4.094
NUMBER OF CUSIPS IN THE ISSUE	24.38	18.43	7	15	20	27	60

Panel B. State level variable							
Variable	Mean	S.D.	P5	P25	Median	P75	P95
FUNDING_RATIO	0.797	0.150	0.576	0.683	0.798	0.892	1.068
INVESTMENT_RISK	0.620	0.096	0.523	0.599	0.634	0.667	0.713
MEDIAN AGE	3.628	0.050	3.546	3.600	3.627	3.658	3.709
FEMALE POPULATION RATIO	0.509	0.006	0.499	0.504	0.510	0.513	0.517
BACHELOR EDUCATION PROPORTION	0.317	0.058	0.230	0.270	0.310	0.360	0.410
PERSONAL INCOME PER CAPITA	10.65	0.226	10.293	10.492	10.64	10.799	11.06
POPULATION	15.702	0.889	13.884	15.16	15.686	16.261	17.367
CHANGE IN POPULATION (%)	0.715	0.653	-0.135	0.257	0.617	1.064	1.879
POVERTY RATE (%)	12.357	2.968	8.100	10.200	11.900	14.200	17.700
CHANGE IN EMPLOYMENT (%)	0.946	1.650	-2.400	0.200	1.200	1.800	3.200

Table 4: Regression analysis of state municipal bonds offering yield spreads on the actuarial-based funding ratio and investment risk of state pension funds

This table presents the regression results of state municipal bonds offering yield spreads on the actuarial-based funding ratio and investment risk of state pension funds. Variable definitions are provided in Appendix A. *p*-value is based on state-level clustered standard errors.

	Dependent variable: Offering yield spreads (YIELD_SPREAD)					
	Model (1)		Model (2)		Model (3)	
	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
FUNDING_RATIO	-0.1490	0.226			-0.1103	0.300
INVESTMENT_RISK			0.1977	0.026	0.1864	0.025
MATURITY	0.0675	0.000	0.0676	0.000	0.0678	0.000
AMOUNT (NATURAL LOG)	-0.0137	0.120	-0.0136	0.121	-0.0137	0.119
CREDIT RATING	0.0055	0.000	0.0055	0.000	0.0055	0.000
CREDIT ENHANCEMENT	-0.0001	0.996	-0.0003	0.991	-0.0001	0.998
PUT DUMMY	-0.6112	0.002	-0.6127	0.002	-0.6138	0.002
CALL DUMMY	0.1126	0.000	0.1121	0.000	0.1119	0.000
INSURANCE	-0.0366	0.057	-0.0356	0.054	-0.0349	0.061
SENIORITY	0.1036	0.106	0.0992	0.125	0.1000	0.119
STATE TAX EXEMPT	-0.0752	0.192	-0.0739	0.193	-0.0757	0.187
FED TAX EXEMPT	-0.7738	0.000	-0.7729	0.000	-0.7727	0.000
AMT DUMMY	-0.3995	0.000	-0.3982	0.000	-0.3988	0.000
REDEPTION DUMMY	-0.1690	0.000	-0.1688	0.000	-0.1685	0.000
SINK DUMMY	0.2297	0.000	0.2289	0.000	0.2291	0.000
GENERAL OBLIGATION	-0.0671	0.019	-0.0675	0.018	-0.0672	0.018
COMPETITIVE ISSUE	-0.1306	0.000	-0.1306	0.000	-0.1305	0.000
UNDERWRITING EXPERIENCE	-0.0025	0.561	-0.0030	0.488	-0.0029	0.491

NUMBER OF CUSIP IN THE ISSUE (NATURAL LOG)	-0.0377	0.001	-0.0384	0.001	-0.0383	0.001
MEDIAN AGE	1.2029	0.118	1.2411	0.098	1.1628	0.125
FEMAL POPULATION RATIO	-18.3682	0.144	-19.2007	0.121	-19.0687	0.125
BACHELOR POPULATION PROPORTION	0.9363	0.367	1.0051	0.324	0.9456	0.356
PER CAPITA PERSONAL INCOME	-0.6764	0.107	-0.6161	0.130	-0.6489	0.114
POPULATION	-0.7457	0.114	-0.6663	0.133	-0.7098	0.120
% CHANGE IN POPULATION	0.0067	0.750	0.0098	0.642	0.0098	0.644
POVERTY RATE	0.0078	0.090	0.0085	0.053	0.0082	0.068
% CHANGE IN EMPLOYMENT	-0.0266	0.009	-0.0266	0.010	-0.0267	0.010
Month fixed effect	YES		YES		YES	
Year fixed effect	YES		YES		YES	
State fixed effect	YES		YES		YES	
R-squared	0.6441		0.6444		0.6445	
No. of observation	152,261		152,261		152,261	

Table 5: Endogeneity

Panel A presents results for two-stage least squared regressions using IVs. In the first stage, dependent variables are *FUNDING_RATIO* and *INVESTMENT_RISK*, and *ACTURIAL FIRM REPUTATION* and *DIRECT FLIGHT* are used as IVs. In the second stage, the regression models are the same as Model (3) in Table 4, except that fitted values of *FUNDING_RATIO* and *INVESTMENT_RISK* from the first stage are used. Panel B presents regression results after the states that have introduced DC or hybrid plans. *CHANGE_DC* is a dummy variable used to test the potential shock caused by the introduction of a DC or a hybrid pension plan. It has a value of 1 if a state introduces a DC plan or hybrid plan in a certain year or thereafter. Panel C presents regression results of states that the Republican party has regained control. *CHANGE_REP* is a dummy variable used to test the potential shock caused by the state political regime. It has a value of 1 for the first year in which the Republicans regain control of the state, zero if otherwise. Republican control refers to those state-years in which the Republicans have a majority in both legislative chambers and the governor is a Republican as well (Ansolabehere and Snyder, 2006). Other variable definitions are provided in Appendix A. The *p*-value is based on state-level clustered standard errors.

Panel A: 2SLS/IV test

	Dependent Variable					
	1st Stage				2nd Stage	
	FUNDING_RATIO		INVESTMENT_RISK		YIELD_SPREAD	
	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
FUNDING_RATIO					-1.3191	0.123
INVESTMENT_RISK					5.1136	0.017
DIRECT FLIGHT	-0.0024	0.028	-0.0065	<0.001		
ACTURIAL FIRM REPUTATION	-0.0155	<0.001	-0.0057	<0.001		
Controls	YES		YES		YES	
Month fixed effect	YES		YES		YES	
Year fixed effect	YES		YES		YES	
State fixed effect	YES		YES		YES	
R-squared	0.8769		0.3834		0.3404	
No. of observations	152,261		152,261		152,261	

Panel B: Regression analysis on the states that have started to introduce DC or hybrid plans

	Dependent Variable: YIELD_SPREAD			
	Coefficient	p-value	Coefficient	p-value
FUNDING_RATIO	-0.1150	0.281	-0.1589	0.110
INVESTMENT_RISK	0.1879	0.020	0.2626	0.001
FUNDING_RATIO*CHANGE_DC			0.1320	0.320
INVESTMENT_RISK*CHANGE_DC			-0.4922	0.009
CHANGE_DC	-0.0216	0.491	0.1932	0.239
Controls	YES		YES	
Month fixed effect	YES		YES	
Year fixed effect	YES		YES	
State fixed effect	YES		YES	
R-squared	0.6445		0.6445	
No. of observation	152,261		152,261	

Panel C: Regression analysis on the states that the Republican Party has regained the control

	Dependent Variable: YIELD_SPREAD			
	Coefficient	p-value	Coefficient	p-value
FUNDING_RATIO	-0.1153	0.280	-0.1032	0.333
INVESTMENT_RISK	0.1900	0.025	0.1750	0.030
FUNDING_RATIO*CHANGE_REP			-0.0290	0.827
INVESTMENT_RISK*CHANGE_REP			-0.2423	0.012
CHANGE_REP	-0.0283	0.163	0.1427	0.340
Controls	YES		YES	
Month fixed effect	YES		YES	
Year fixed effect	YES		YES	
State fixed effect	YES		YES	
R-squared	0.6445		0.6446	
No. of observation	152,261		152,261	

Table 6: Regression analysis of influence channels

Panel A presents results for the regressions of offering yield spreads on funding ratio and risky allocation of state pensions for the subsamples of stable pension contribution states (those states with a standard deviation of contribution ratio larger than the median of the sample) vs. non-stable pension contribution states (those states with a standard deviation of contribution ratio smaller than or equal to the median of the sample). Panel B presents results for the regressions of offering yield spread on funding ratio and risky allocation of state pensions for the subsamples of states with a rating better than or equal to AA- in S&P vs. states with rating worse than AA- in S&P.

Panel A: Subsample analysis: States with stable pension contributions vs. volatile contributions

	Dependent Variable: YIELD_SPREAD			
	Stable Contribution Subsample		Volatile Contribution Subsample	
	Coefficient	p-value	Coefficient	p-value
FUNDING_RATIO	-0.1414	0.548	-0.1424	0.192
INVESTMENT_RISK	0.1093	0.278	0.2410	0.010
Controls	YES		YES	
Month fixed effect	YES		YES	
Year fixed effect	YES		YES	
State fixed effect	YES		YES	
R-squared	0.6398		0.6541	
No. of observation	72,035		80,226	

Panel B: Subsample analysis based on state ratings: Non-constrained vs. constrained states

Variables	Dependent variable: YIELD_SPREAD			
	Non-constrained States Subsample		Constrained States Subsample	
	Coefficient	p-value	Coefficient	p-value
FUNDING_RATIO	-0.0430	0.663	-0.1938	0.838
INVESTMENT_RISK	0.1490	0.078	0.8556	0.020
Controls	YES		YES	
Month fixed effect	YES		YES	
Year fixed effect	YES		YES	
State fixed effect	YES		YES	
R-squared	0.6475		0.7301	
No. of observation	139,185		13,076	

Table 7: Regression of state municipal bonds offering yield spreads on market-based funding ratio and investment risk of state pension funds

This table presents results for regressions of offering yield spreads on market-based funding ratio and risky allocation of state pension funds. Model (1) is the same as Model 3 in Table 4, except that a market-based funding ratio instead of an actuarial-based funding ratio is used. In Model (2), two more variables (pension contribution ratio and pension funds' past 3-year returns) are controlled, in addition to those in Model (1). the *p*-value is based on state-level clustered standard errors.

	Dependent variable: YIELD_SPREAD			
	Model (1)		Model (2)	
	Coefficient	*p*-value	Coefficient	*p*-value
Mkt-FUNDING_RATIO	-0.0013	0.864	-0.0007	0.919
Mkt-INVESTMENT_RISK	0.1550	0.043	0.1717	0.017
CONTRIBUTION RATIO			-1.5809	0.009
PENSION FUND 3-YEAR RETURNS			-1.1162	0.096
Other Controls	YES		YES	
Month fixed effect	YES		YES	
Year fixed effect	YES		YES	
State fixed effect	YES		YES	
R-squared	0.6544		0.6547	
No. of observation	110,977		110,977	

Table 8: Tests on a legal framework, public employee unionization, and general obligation vs. revenue bonds

Panel A presents results for the regressions of state municipal bonds offering yield spreads on the actuarial-based funding ratio and investment risk of state pension plans for the subsamples of states with high public employee union membership (those states with a proportion of public employee union membership higher than the median level of the sample) vs. states with low public employee union membership (those states with the proportion of public employee union membership smaller than or equal to the median level of the sample). Panel B presents results for the regressions of offering yield spreads on the actuarial-based funding ratio and investment risk of state pension plans for the subsamples of states with high law protection of pension (those states with law protection of pension higher than the median level of the sample) vs. states with low law protection of pension (those states with law protection of pension lower than or equal to the median level of the sample). Panel C presents results for the regressions of offering yield spreads on the actuarial-based funding ratio and investment risk of state pension plans for the subsamples of general obligation bonds vs. revenue bonds. All the models are the same as in Model (3) of Table 4. For the purpose of brevity, coefficients on other control variables are not reported. The *p*-value is based on state-level clustered standard errors.

Panel A: Regression of state municipal bonds offering yield spreads on the actuarial-based funding ratio and risky allocation of Pension funds by state public employee union membership

Variables	Dependent variable: MUNIS_YIELDS			
	High union membership		Low union membership	
	Coefficient	*p*-value	Coefficient	*p*-value
FUNDING_RATIO	-0.0617	0.726	-0.2976	0.031
INVESTMENT_RISK	0.1985	0.045	0.1140	0.549
Controls	YES		YES	
Month fixed effect	YES		YES	
Year fixed effect	YES		YES	
State fixed effect	YES		YES	
R-squared	0.6360		0.6679	
No. of observations	74,494		77,767	

Panel B: Regression of state municipal bonds offering yield spreads on the actuarial-based funding ratio and investment risk of pension funds by state law of pension protection

Variables	Dependent variable: YIELD_SPREAD			
	High law protection		Low law protection	
	Coefficient	*p*-value	Coefficient	*p*-value
FUNDING_RATIO	-0.1939	0.176	-0.0345	0.793
INVESTMENT_RISK	0.2133	0.050	0.0290	0.828
Controls	YES		YES	
Month fixed effect	YES		YES	
Year fixed effect	YES		YES	
State sixed effect	YES		YES	
R-squared	0.6769		0.6198	
No. of observations	72,747		79,514	

Panel C: Regression of state municipal bonds offering yield spreads on the actuarial-based funding ratio and investment risk of state pension funds for general obligation bonds and revenue bonds

Variables	Dependent variable: YIELD_SPREAD			
	General obligation bonds		Revenue bonds	
	Coefficient	*p*-value	Coefficient	*p*-value
FUNDING_RATIO	-0.1733	0.275	-0.1241	0.296
INVESTMENT_RISK	0.1596	0.057	0.1488	0.402
Controls	YES		YES	
Month fixed effect	YES		YES	
Year fixed effect	YES		YES	
State fixed effect	YES		YES	
R-squared	0.6531		0.5705	
No. of observations	73,577		78,684	