Risk-Taking Behavior Of Public Pension Plans Before And After The Financial Crisis Of 2008

Youngkyun Park, University of Idaho, USA

ABSTRACT

This paper investigates whether public pension plans' risk-taking behavior has changed after the recent financial crisis of 2008 by testing two contrasting hypotheses on pension funding: risk transfer and risk management hypotheses. In managing pension assets, public pension plan sponsors may have an incentive for risk transfer because underfunded pension obligations can be shifted to future taxpayers (risk transfer hypothesis). Facing a budget constraint, they may also have an incentive for risk management because they would prefer to stabilize their contributions (risk management hypothesis). Using a sample of 126 public pension plans for the period of 2001–2011, this paper finds that public pension plans' risk-taking behavior has changed after the financial crisis of 2008. Before the financial crisis, public pension plan sponsors invest more in equities when a large required contribution is expected, which is consistent with the risk transfer hypothesis. After the financial crisis, however, the plan sponsors invest less in equities when a large required contribution is expected, which is consistent with the risk management hypothesis. The findings suggest that public pension plans' risk-taking behavior is not constant over time, but can be varied depending on market conditions.

Keywords: Public Pension Plan; Risk Management; Risk Transfer

1. INTRODUCTION

During the recent financial crisis of 2008, public-sector pension plans experienced large declines in the value of their investment portfolios. For 101 public pension plans, the market value of pension assets in fiscal year 2009 ending on June 30 dropped by about 25% to $2.1 billion from $2.8 billion in fiscal year 2007 ending on June 30 (Brainard, 2008, 2010). The declines in the value of public pension assets have brought attention to several issues, such as funding status, the rates of return used to discount plan liabilities (known as the "discount rate"), and investment strategies (Government Accountability Office [GAO], 2010a). And given public-sector plan sponsors' limited ability to increase employee contributions, increasing deficits in pension plans has raised the probability that employer contributions will have to be made to make up for the deficits (GAO, 2010b).

Public plan sponsors have sought stabilizing their contributions to the plans using actuarial methodologies. In particular, in order to maintain a stable contribution as a percentage of payroll over time, plan sponsors have adopted a smoothing period for investment losses and an amortization period for unfunded accumulated liability (Munnell, Aubry, & Muldoon, 2008). However, responding to increasing required contributions to the plans as a consequence of underfunding, plan sponsors may invest more in high risk assets, such as equities, with an expectation that earnings from the investment would reduce the required employer contributions. This risk-taking behavior of public pension sponsors has been supported by the findings of recent studies on public pension plans (e.g., Pennacchi & Rastad, 2011; Mohan & Zhang, 2012).

However, after experiencing a significant underfunding during the financial crisis of 2008, public pension plans' risk-taking behavior may be changed. For example, according to the Public Fund Surveys covering 126 plans,

the average allocation to equities in fiscal year 2009 dropped to 52.1% from 59.7% in fiscal year 2007, while the average allocation to fixed income in fiscal year 2009 increased to 29.0% from 26.6% in fiscal year 2007 (Brainard, 2008, 2010). This paper examines whether public pension plans' risk-taking behavior has changed after the recent financial crisis by testing two contrasting hypotheses on pension funding: risk transfer (e.g., Sharpe, 1976; Treynor, 1977; Epple & Schipper, 1981; Inman, 1982; Gold, 2003) and risk management (Rauh, 2009) hypotheses. For the examination, the paper uses the recent data from the Public Plans Database (PPD) maintained by the Center for Retirement Research at Boston College.

To test the two hypotheses, this study investigates a relationship between an employer contribution gap—the difference between the projected annual required contribution and actual employer contribution as a percentage of payroll—in the previous period and the asset allocation in the current period. Prior studies on public pension plan asset investments focus on a relationship between a funding ratio (defined by a ratio of pension asset over pension liability) in the previous period and the asset allocation in the current period (e.g., Pennacchi & Rastad, 2011; Mohan & Zhang, 2012). However, the funding ratio may not directly affect public pension plans' risk-taking behavior because the funding ratio can be affected by different assumptions on pension assets (e.g., market or actuarial value of pension assets) and/or pension liabilities (e.g., different discount rates). Different from the funding ratio, the employer contribution gap may directly affect the risk-taking behavior of public pension plans; a large employer contribution gap may need to be resolved by increasing employer contributions, but the plan sponsor may be able to reduce the required employer contributions by investment earnings. Thus, an employer contribution gap in the previous period may affect more directly the plan sponsor's risk-taking behavior in managing pension assets in the next period than a funding ratio in the previous period.

While controlling for plan fixed effects, I find evidence that the risk-taking behavior of public pension plan sponsors has changed after the financial crisis. The risk transfer hypothesis is supported in the pre-crisis period, which is consistent with the findings of Pennacchi and Rastad (2011) and Mohan and Zhang (2012). However, the risk management hypothesis is supported in the post-crisis period, which is consistent with the finding of Rauh (2009) with corporate pension plans. This study extends the extant literature on public pension funding by presenting that the risk-taking behavior of public pension plans has changed to risk management from risk transfer after the financial crisis. This finding may suggest that public pension plans' risk-taking behavior is not constant over time, but can be varied depending on market conditions.

The remainder of the paper is organized as follows. Section 2 provides a brief review on public pension benefit funding as institutional background. Section 3 addresses two hypotheses related to risk-taking behavior of public pension plans. Section 4 describes data and model specification to test the hypotheses. Section 5 presents empirical results. Section 6 concludes the paper.

2. INSTITUTIONAL BACKGROUND: PUBLIC PENSION BENEFIT FUNDING

Different from private-sector defined benefit plans, public pension plans are not funded entirely by employers; they are financed by employees as well as employers. Public pension revenue relies on three sources: earnings from investments, government (employer) contributions, and employee contributions. Among these sources of income, investment earnings typically have accounted for the largest portion of plan funding because public pension plans are generally financed on a funded basis rather than a pay-as-you-go basis. On average from 1982 to 2010, 61% of public pension benefit payments are funded through investment earnings, 26% from employer contributions, and 13% from employee contributions (National Association of State Retirement Administrators [NASRA], 2013). Since public pension funding depends largely on investment earnings, negative (positive) returns on investments decrease (increase) the funding status of pension plans. Sharp improvements or reductions in funding status, however, are gradually recognized in financial statements because of the use of a smoothing period (usually five years), which is applied as a way to minimize sharp swings in annual funding requirements and stabilize plan sponsors' contributions over time (e.g., Munnell et al., 2008).

Although public pension plans are not subject to ERISA's funding standards, they usually follow the guidelines specified in Governmental Accounting Standards Board Statement (GASB). In particular, GASB Statement No. 25 addresses that states should make annual required contributions (ARC) that include the normal cost—the cost of benefits accruing in the current year—and amortized payments for unfunded actuarial accrued

liability (unfunded actuarial liability). However, states do not always contribute enough funds to cover the ARC. For example, according to the recent data from Public Plans Database (PPD), 58 plans out of 125 public pension plans fully funded their required contributions in fiscal year 2010. Among the remaining plans that did not meet their required contributions, 11 plans contributed less than 50% of the required contributions.

As another parameter that can affect pension funding, GASB Statement No. 27 specifies that the expected long-term rate of return on pension assets should be used as a discount rate for the evaluation of pension liability. The investment return assumption directly affects employer required contributions through its impact on anticipated asset values, and it also influences the required contributions indirectly through the liability value. A higher investment return assumption (i.e., a higher discount rate for pension liability) would lead to lower ARCs. In fiscal year 2011, most plans (42% of 126 plans) adopt 8% as an investment return assumption (a discount rate), but 17% of the plans use an investment return assumption greater than 8% (Public Fund Survey, 2012).

3. LITERATURE REVIEW AND HYPOTHESES

This section reviews the literature on pension funding in corporate and public pension plans and discusses two hypotheses, risk transfer and risk management hypotheses, for examining public pension plans' risk-taking behavior. To test the two hypotheses, I investigate a relationship between an employer contribution gap—the difference between the projected annual required contribution and actual employer contribution as a percentage of payroll—in the previous period and the asset allocation in the current period. This is different from prior studies (e.g., Pennacchi & Rastad, 2011; Mohan & Zhang, 2012) that focus on a relationship between a funding ratio—a ratio of pension asset over pension liability—in the previous period and the asset allocation in the current period.

3.1 Risk Transfer Hypothesis

Similar to corporate defined benefit (DB) pension plan sponsors, public pension plan sponsors may have a moral hazard (or risk transfer) incentive in managing pension assets. Corporate pension plan sponsors may have an incentive to invest in risky assets because they are insured by the Pension Benefit Guaranty Corporation (PBGC). For example, Sharpe (1976) and Treynor (1977) argue that moral hazard incentives for firms to underfund pension plans and invest the pension assets in risky securities can be created by firms' efforts to maximize the put option value of the PBGC insurance. For underfunded public pension plans, the government can raise taxes to fund the plans, and as a result, the underfunded pension obligations can be shifted to future taxpayers (Gold, 2003). Thus, facing the unpopular choices of raising taxes to increase employer contributions in the short run, the plan sponsor may increase a share of risky securities in the plan assets because earnings from the investments may reduce the required employer contributions (Bader & Gold, 2007; Lucas & Zeldes, 2009). Politicians are "not concerned about long-term funding issues because they operate under a relatively short time horizon" (Giertz & Papke, 2007, p. 314). Therefore, if the risk transfer hypothesis holds, a *positive* relation is predicted between the employer contribution gap in the previous period and an equity share of pension assets in the current period.

3.2 Risk Management Hypothesis

In a context of corporate DB plans, Rauh (2009) argues that corporate plan sponsors have risk management incentives to avoid costly financial distress in pension fund investing. Unexpected poor performance in pension assets requires the firm to make cash contributions to pension funds, which in turn reduce capital expenditures (Rauh, 2006). Similar to corporate DB plans, unexpected increases in required contributions to public pension plans may reduce services for schools or police, which would correspond to capital expenditures of companies, because the state/municipal budget is fixed in the short run (Mohan & Zhang, 2012). Because public pension funding relies largely on investment earnings, volatility in financial markets would result in considerable variations in required employer contributions. As public plan sponsors have sought stabilizing their contributions to the plans using actuarial methodologies, they would prefer to have predictable pension contributions.[1] From this risk management

[1] In public pension plans, employer contributions are designed to remain level as a percentage of payroll. For example, most public pension plans are currently valued using the "entry-age normal actuarial cost method." This method is designed to maintain a level contribution as a percentage of payroll over time, and aims to help governments plan and budget their contributions to pension plans (National Conference on Public Employee Retirement System, 2008).

perspective, when public pension plan sponsors recognize a large employer contribution gap between projected and actual employer contributions, they may reduce investment in risky assets, which may result in more variable contributions. Thus, if the risk management hypothesis holds, a *negative* relation is predicted between the employer contribution gap in the previous period and an equity share of pension assets in the current period.

3.3 Risk-Taking Behavior Before and After the Financial Crisis of 2008

For the recent financial crisis of 2008, public-sector pension plans experienced a significant drop in the value of their assets and, thereby, a significant underfunding of the plans. The financial crisis may change the risk-taking behavior of public pension plan sponsors. Thus, if there is any change in the risk-taking behavior after the financial crisis, the relation between the employer contribution gap and an equity share of pension assets would change from positive to negative or *vice versa*.

4. DATA AND MODEL SPECIFICATION

This study uses fiscal years 2001 through 2011 from the Public Plans Database (PPD) produced by the Center for Retirement Research at Boston College. The database covers 126 state and local pension plans for 50 states and the District of Columbia. Each state has at least one pension system, and each system can have multiple plans for different employee groups, such as teachers, police and firefighters, and state and local government employees. The public pension plans held $23.1 billion pension assets on average at the end of fiscal year 2011.[2]

To test the two hypotheses for the risk-taking behavior of public pension plans, I use the following model:

$$Equity_{i,t} = ErContrGap_{i,t-1} + InvRet_{i,t-1} + FundingRatio_{i,t-1} + ActiveAnnuitant_{i,t} + PlanSize_{i,t} + BoardComp_{i,t} + Teacher_{i,t} + General_{i,t} + InvCouncil_{i,t} + Year_t + Plan_i + e_{i,t} \quad (1)$$

where

$Equity_{i,t}$ = Equity share of pension plan assets for plan *i* at time *t*,
$ErContrGap_{i,t-1} = E_{t-1}[ARC_{i,t}] - ErContr_{i,t-1}$,
$E_{t-1}[ARC_{i,t}]$ = Projected ARC$_t$ as a percentage of payroll for plan *i* at time *t*-1,
$ErContr_{i,t-1}$ = Actual employer contribution as a percentage of payroll for plan *i* at time *t*-1,
$FundingRatio_{i,t-1}$ = Actuarial funding ratio (a ratio of actuarial pension assets over actuarial pension liabilities) for plan *i* at time *t*-1,
$InvRet_{i,t-1}$ = Investment return assumption (or discount rate) for plan *i* at time *t*,
$ActiveAnnuitant_{i,t}$ = Ratio of active participants to annuitants for plan *i* at time *t*,
$PlanSize_{i,t}$ = Natural logarithm of the market value of pension assets for plan *i* at time *t*,
$BoardComp_{i,t}$ = Ratio of the total plan participants on the board to the total board members for plan *i* at time *t*,
$Teacher_{i,t}$ = A dummy variable that takes 1 if plan *i* is a teacher's plan and 0 otherwise at time *t*,
$General_{i,t}$ = A dummy variable that takes 1 if plan *i* is a general plan that covers public employees excluding teachers and police and firefighters and 0 otherwise at time *t*,
$InvCouncil_{i,t}$ = A dummy variable that takes 1 if plan *i* has a separate investment council and 0 otherwise at time *t*.

Equation 1 includes an employer contribution gap (*ErContrGap*) as one of the key independent variables. A variable of *ErContrGap* is defined by a gap between projected *ARC$_t$* at time *t*-1 and actual employer contribution at time *t*-1. A larger employer contribution gap indicates a larger pressure for employer contributions because the plan sponsor would meet larger required contributions in the next period, all other things being equal. In addition, Equation 1 includes the investment return assumption (*InvRet*) (or discount rate) in the previous period because public pension plans selecting a higher discount rate are more likely to invest in higher risk assets than those who use a lower discount rate (e.g., Park, 2009; Pennacchi & Rastad, 2011; Mohan & Zhang, 2012).

[2] When the author writes this article, the PPD provides the information on the market value of plan assets for 99 state and local pension plans for fiscal year 2011. The PPD does not include the information for the remaining 27 plans yet.

To test the two hypotheses for public pension plan risk-taking behavior in the pre- and post-financial crisis periods, I estimate Equation 1 for the pre-crisis period (2001-2007) and the post-crisis period (2008-2011). Since an actuarial funding ratio (*FundingRatio*) would be significantly (negatively) correlated with an employer contribution gap (*ErContrGap*), I further estimate Equation 1 by different funding levels (low vs. high) for each period to control for potential collinearity between the two variables.

5. EMPIRICAL RESULTS

5.1 Descriptive Statistics

Table 1 provides summary statistics for all plans during the period of 2001-2011 for key variables. Panel A presents plan characteristics such as actuarial funding ratios, investment return assumptions (or discount rates), actual employer contribution as a percentage of payroll, employer contribution gaps, and other characteristics. The public pension plans in the sample show a funding ratio of 84–85% on average during the period. A majority of the public pension plans adopt 8% as an investment return assumption (or a discount rate). Employer contribution gaps show a wide dispersion: the standard deviation is as large as over seven times the mean. The pension plans have a smoothing period of 4 years and an amortization period of about 27 years on average. Teachers' plans account for 31.7%, police and firefighters' plans 9.6%, and general plans 58.7% of the public pension plans. About 35% of the plans have separate investment councils.

Table 1: Descriptive Statistics

	Mean	Std. Dev.	P25	Median	P75	N
Panel A: Descriptive Statistics of Plan Characteristics						
Actuarial funding ratio	0.843	0.166	0.741	0.854	0.972	1,313
Investment return assumption	0.080	0.004	0.078	0.080	0.083	1,303
Actual employer contribution (as a percentage of payroll)	0.106	0.121	0.051	0.083	0.122	1,241
Employer contribution gap: Difference between projected employer annual required contribution and actual employer contribution (as a percentage of payroll)	0.044	0.322	0.003	0.023	0.064	940
Ratio of active participants to annuitants	3.125	7.996	1.628	2.002	2.509	1,251
Smoothing period (year)	4.055	2.186	3.000	5.000	5.000	1,266
Amortization period (year)	26.650	11.277	20.000	29.000	30.000	1,161
Teachers' plan	0.317	0.466	0.000	0.000	1.000	1,386
Police/firefighters' plan	0.096	0.294	0.000	0.000	0.000	1,386
General plan	0.587	0.492	0.000	1.000	1.000	1,386
Separate investment council	0.349	0.477	0.000	0.000	1.000	1,386
Market value of plan assets ($ bil.)	18.26	28.21	3.74	8.88	19.84	1,358
Panel B: Descriptive Statistics of Plan Asset Allocation						
Equities	0.552	0.109	0.496	0.570	0.623	1,353
Fixed income	0.283	0.097	0.229	0.266	0.330	1,353
Real estate	0.056	0.048	0.005	0.052	0.088	1,332
Alternatives	0.036	0.063	0.000	0.000	0.051	1,325
Cash and short-term assets	0.023	0.030	0.003	0.014	0.032	1,332
Other assets	0.052	0.069	0.000	0.022	0.090	1,324

Panel B presents plan asset allocation to equities, fixed income, real estate, alternatives (including private equity and hedge funds), cash and short-term assets, and other assets. On average 55.2% of the plan assets are invested in equities, 28.3% in fixed income, 5.6% in real estate, and 3.6% in alternatives during the period of 2001–2011.

5.2 Public Pension Plans: Pre- and Post-Financial Crisis

Table 2 presents whether plan characteristics, asset allocations, and investment return assumptions have changed since the financial crisis of 2008. Panel A shows changes in plan characteristics after the financial crisis.

The ratio of active participants to annuitants has significantly reduced because of a significant increase in the number of annuitants. The funding status of public pension plans has deteriorated by 10.2 percentage points on average. Actual employer contribution as a percentage of payroll has increased by 2.3 percentage points on average, but the employer contribution gap as a percentage of payroll has rather increased by 5.2 percentage points since the financial crisis. Panel B presents changes in asset allocations after the financial crisis. A share of equities in pension assets has significantly decreased by 7.0 percentage points on average, while a share of fixed income has significantly decreased by 2.2 percentage points on average. In contrast, shares of real estate and alternatives have significantly increased by 1.6 and 4.1 percentage points, respectively. Panel C presents that more pension plans have adopted a low discount rate (lower than 8%) after the financial crisis. Before the financial crisis, 29.6% of the plans adopted a high discount rate (greater than 8%), while 24.9% adopted a low discount rate (lower than 8%). After the financial crisis, however, 23.2% of the plans adopted a high discount rate, while 33.9% adopted a low discount rate.

Table 2: Public Pension Plans: Pre- and Post-Financial Crisis

	Pre-Crisis (2001 To 2007)			Post-Crisis (2008 To 2011)			Difference (= Post – Pre)	
	Mean	**Median**	**N**	**Mean**	**Median**	**N**	**Mean**	**Median**
Panel A: Plan Characteristics								
Ratio of active participants to annuitants	3.589	2.145	823	2.233	1.805	428	-1.356**	-0.340***
Number of active participants (000s)	97.43	61.39	823	104.38	61.76	428	6.94	0.37
Number of annuitants (000s)	44.18	28.04	823	55.90	35.52	428	11.73***	7.48***
Actuarial funding ratio	0.878	0.893	866	0.776	0.777	323	-0.102***	-0.116***
Actual employer contribution (as a percentage of payroll)	0.098	0.075	817	0.121	0.098	306	0.023***	0.023***
Employer contribution gap (as a percentage of payroll)	0.024	0.020	579	0.076	0.030	361	0.052*	0.010***
Market value of plan assets ($ bil.)	17.63	8.79	881	19.43	8.96	477	1.80	0.17
Panel B: Plan Asset Allocation								
Equities	0.577	0.591	881	0.507	0.522	472	-0.070***	-0.069***
Fixed income	0.291	0.273	881	0.269	0.256	472	-0.022***	-0.018***
Real estate	0.050	0.047	865	0.066	0.060	467	0.016***	0.013***
Alternatives	0.022	0.000	862	0.063	0.030	463	0.041***	0.030***
Cash and short-term assets	0.023	0.014	867	0.021	0.014	465	-0.002	0.000
Panel C: Investment Return (Discount Rate) Assumption								
Plans using an 8% discount rate	0.0800	0.0800	393 (45.5%)	0.0800	0.0800	188 (42.8%)		
Plans using a *high* discount rate †	0.0843	0.0850	256 (29.6%)	0.0838	0.0838	102 (23.2%)	-0.0005***	-0.0013**
Plans using a *low* discount rate †	0.0742	0.0750	215 (24.9%)	0.0745	0.0750	149 (33.9%)	0.0002	0.0000*

† A high (or low) discount rate indicates whether a plan's discount rate is greater (or lower) than 8%. Note: A two-sample *t*-test with unequal variances is used to compare the means. A Wilcoxon rank sum test is used to compare the medians. ***, **, and * indicates significance at the 1%, 5%, and 10% levels, respectively.

5.3 Regression Analysis

To examine public pension plans' risk-taking behavior in the pre- and post-financial crisis periods, I estimate Equation 1 for the pre-crisis period (2001-2007) and the post-crisis period (2008-2011). Table 3 presents the regression results. Columns (1) and (2) show results for the pre-crisis period, while columns (3) and (4) show results for the post-crisis period. Regarding model specifications, columns (2) and (4) include plan fixed effects, but columns (1) and (3) do not.

Table 3: Regression Analysis of Public Pension Plan Risk-Taking Behavior: Pre- and Post-Financial Crisis

Dependent Variable:	**Pre-Crisis (2001 to 2007)**		**Post-Crisis (2008 to 2011)**	
Portfolio share of equities at *t*(*Equity*$_t$)	**(1)**	**(2)**	**(3)**	**(4)**
Employer contribution gap at *t*-1	0.065**	0.028**	0.065	-0.055**
(*ErContrGap*$_{t-1}$)	(0.030)	(0.013)	(0.055)	(0.021)
Investment return assumption at *t*-1	3.964***	3.094	-0.396	-0.176
(*InvRet*$_{t-1}$)	(1.493)	(1.980)	(1.476)	(0.826)
Actuarial funding ratio at *t*-1	-0.032	0.006	-0.058	-0.174
(*FundingRatio*$_{t-1}$)	(0.046)	(0.049)	(0.066)	(0.128)
Ratio of active participants to annuitants	0.011	-0.017*	-0.003	-0.019
at *t* (*ActiveAnnuitant*$_t$)	(0.007)	(0.010)	(0.010)	(0.040)
Plan size at *t* (*PlanSize*$_t$)	0.010	-0.055	-0.005	0.152***
	(0.007)	(0.043)	(0.007)	(0.057)
Board composition at *t* (*BoardComp*$_t$)	0.076**		0.146**	
	(0.035)		(0.060)	
Teachers' plan at *t* (*Teacher*$_t$)	0.030		0.075*	
	(0.032)		(0.044)	
General state plan at *t* (*General*$_t$)	0.039		0.070	
	(0.031)		(0.043)	
Separate investment council at *t*	0.033*		-0.014	
(*InvCouncil*$_t$)	(0.017)		(0.020)	
Time fixed effects	Yes	Yes	Yes	Yes
Plan fixed effects	No	Yes	No	Yes
Hausman test for model specification: Prob > χ^2		0.005		0.009
Number of plans	85	85	103	103
Number of observations	463	463	330	330
R^2	0.237	0.244	0.166	0.164

Note: Numbers in parenthesis are robust standard errors, which are adjusted for plan clusters. ***, **, and * indicates significance at the 1%, 5%, and 10% levels, respectively.

When plan fixed effects are controlled for, the results show that public pension plan sponsors' risk-taking behavior has changed after the financial crisis of 2008. Employer contribution gap at *t*-1 (*ErContrGap*$_{t-1}$) is significantly *positively* associated with equity allocation at *t* (*Equity*$_t$) for the pre-crisis period, whereas the variable is significantly *negatively* associated with allocations to equities for the post-crisis period. The positive relation between the two variables for the pre-crisis period indicates that public pension plan sponsors tend to increase a share of equities in pension portfolios when the employer contribution gap is widened, supporting the risk transfer hypothesis. In contrast, the negative relation between the two variables for the post-crisis period indicates that the plan sponsors tend to decrease a share of equities when the employer contribution pressure becomes increased, supporting the risk management hypothesis.

A plan's employer contribution gap would be closely related to its funding ratio because a plan's ARC is affected by amortized payments for unfunded actuarial accrued liability as well as employer normal cost. In the sample, the two variables, *ErContrGap* and *FundingRatio*, are significantly negatively correlated (Pearson's r = -0.108 with P-value < 0.01). Thus, in order to control for potential collinearity between the two variables, Equation (1) is estimated for two different funding levels (low vs. high) for each period. Two funding levels are categorized with a threshold of an 83% of actuarial funding ratio. The threshold is the mean of the average actuarial funding ratios in the pre- and post-crisis periods. If a plan's funding ratio is greater or equal to 83%, the plan is regarded as one that has a high funding level. Otherwise, a plan is regarded as one that has a low funding level.

Table 4 presents regression results by two different funding levels for each period. For the pre-crisis period, when the employer contribution gap is increased, public pension plans having a low funding level at *t*-1 do not significantly increase their risk-taking behavior at *t* (columns (1) and (2)). However, those having a high funding level at *t*-1 tend to increase equity allocations at *t* (columns (3) and (4)). The results indicate that, for the pre-crisis period, the risk-taking behavior of public pension plans that face increasing employer contribution pressure (the risk transfer hypothesis) applies only to the plans in a high funding level, not all the public pension plans. In contrast, for the post-crisis period, when the employer contribution gap is increased at *t*-1, all the public pension plans (plans in

both low and high funding levels) tend to decrease a share of equities at *t* (columns (6) and (8)), the result which supports the risk management hypothesis.[3] Overall, the regression results presented in the table suggest that the risk-taking behavior of public pension plans has changed after the financial crisis of 2008.

Table 4: Regression Analysis of Public Pension Plan Risk-Taking Behavior by Funding Levels: Pre- and Post-Financial Crisis

Dependent Variable: $Equity_t$	Pre-Crisis (2001 to 2007)				Post-Crisis (2008 to 2011)			
	Low Funding Level at t-1†		High Funding Level at t-1†		Low Funding Level at t-1†		High Funding Level at t-1†	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$ErContrGap_{t-1}$	-0.003	0.017	0.100**	0.019***	0.072	-0.056***	0.011	-0.118**
	(0.039)	(0.025)	(0.039)	(0.005)	(0.070)	(0.017)	(0.069)	(0.053)
$InvRet_{t-1}$	3.038	2.710	3.842**	3.802*	-0.241	-1.118	-1.500	2.818***
	(2.737)	(4.502)	(1.580)	(2.022)	(1.831)	(0.714)	(2.718)	(0.895)
$ActiveAnnuitant_t$	0.011	-0.025	0.014**	-0.017	-0.015	0.196*	-0.004	-0.097*
	(0.017)	(0.024)	(0.007)	(0.010)	(0.019)	(0.111)	(0.010)	(0.050)
$PlanSize_t$	-0.004	-0.048	0.013*	-0.094	-0.007	0.234***	-0.004	0.254***
	(0.0080	(0.046)	(0.008)	(0.078)	(0.010)	(0.062)	(0.008)	(0.082)
$BoardComp_t$	0.092*		0.074*		0.226***		0.068	
	(0.047)		(0.040)		(0.079)		(0.062)	
$Teacher_t$	0.002		0.052		0.078		0.076	
	(0.024)		(0.038)		(0.051)		(0.063)	
$General_t$	0.0005		0.065*		0.083*		0.054	
	(0.024)		(0.037)		(0.050)		(0.060)	
$InvCouncil_t$	0.050**		0.030		-0.041		0.017	
	(0.021)		(0.020)		(0.025)		(0.026)	
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plan fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Hausman test for model specification: Prob > χ^2		0.677		0.018		0.024		0.021
Number of plans	49	49	69	69	73	73	59	59
Number of observations	170	170	293	293	196	196	134	134
R^2	0.243	0.142	0.281	0.332	0.293	0.261	0.074	0.266

† A high (low) funding level is categorized with a threshold of an 83% of actuarial funding ratio. Note: Numbers in parenthesis are robust standard errors, which are adjusted for plan clusters. ***, **, and * indicates significance at the 1%, 5%, and 10% levels, respectively.

6. CONCLUSION

This paper examines public pension plans' risk-taking behavior by testing two contrasting hypotheses: risk transfer and risk management hypotheses. Public pension plan sponsors may have a moral hazard incentive in managing pension plan assets because taxpayers are ultimately responsible for underfunded plans. The argument is related to the risk transfer hypothesis. In contrast, public pension plan sponsors would prefer to reduce potential variation in employer contributions because unexpected increases in required contributions to public pension plans may have to reduce services for schools or police in a given state/municipal budget. This argument is related to the risk management hypothesis. Risk-taking behavior of public pension plans that could be explained by either hypothesis would be changed after the financial crisis of 2008 because most pension plans experienced a significant underfunding during the financial crisis. In this context, the paper investigates whether public pension plans' risk-taking behavior has changed after the financial crisis.

Using the sample of 126 public pension plans for the period of 2001-2011, I find that public pension plans' risk-taking behavior has changed after the financial crisis of 2008. Before the financial crisis, public pension plan sponsors invest more in equities when a large required contribution is expected. In particular, this risk-taking behavior is observed among the plans that are in a high funding level in the previous year. The findings for the pre-crisis period are consistent with those documented by Pennacchi and Rastad (2011) and Mohan and Zhang (2011),

[3] Because the plan characteristics variables—plan size, plan types, and separate investment council—may not reflect unobserved plan characteristics, a model controlling for plan fixed effects is preferred to one without the effects. In addition, Hausman test results (reported in Tables 3 and 4) indicate that the model should include the plan fixed effects.

supporting the risk transfer hypothesis. After the financial crisis, however, the plan sponsors' risk-taking behavior has changed to support the risk management hypothesis. The change in risk-taking behavior is observed across the plans regardless of their funding levels. Thus, the findings suggest that public pension plans' risk-taking behavior is not constant over time, but can be varied depending on market conditions.

AUTHOR INFORMATION

Youngkyun Park, Ph.D., Assistant Professor of Finance, College of Business and Economics, University of Idaho, 875 Perimeter Drive MS 3161, Moscow, ID 83844-3161, USA. E-mail: youngpark@uidaho.edu

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