Pension Fund Asset Allocation and Liability Discount Rates*

Online Appendices

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Appendix A: Stylized scenarios of the pension contribution payments and funding status after discount rate changes

The regulatory incentives hypothesis argues that the regulation linking the liability discount rate and the expected rate of return on assets gives U.S. public pension funds an incentive to increase their allocation to risky assets with higher expected returns in order to justify a higher liability discount rate and, as a consequence, lower the reported value of the liabilities. When testing this hypothesis, we posit that within U.S. public pension funds, more mature funds have stronger incentives to maintain a higher liability discount rate, because reducing the discount rate creates larger immediate economic costs for them. In this appendix, we use different stylized scenarios to clarify this assertion that more mature funds face larger economic costs if they lower their liability discount rate by exploring how discount rate changes affect the contribution payments and pension funding status depending on pension fund maturity.

Our argument that more mature pension funds have a stronger incentive to maintain higher liability discount rates may not be immediately obvious, because more mature pension funds have shorter-duration liabilities. As a result, the present value of their liabilities and thus their funding ratio are less sensitive to changes in the liability discount rate than for funds whose liabilities have longer durations. However, our argument is not based on the changes in fund's funding ratio, but on the changes in reported level of underfunding per participant and the corresponding additional annual required contributions payments funds have to make if they are underfunded. These contribution payments represent a direct economic cost for the pension fund, whose amount depends upon the dollar value of the funding deficit.

More mature pension funds have larger accrued liabilities for a given number of participants, since on average these participants have accrued liabilities for a longer period of time. If the pension fund is underfunded, as essentially all U.S. public pension funds were during the recent sample period (see Appendix Figure E.1), then it is required to pay 'catch-up' (deficit-reduction) contributions to amortize the total unfunded accrued liability (GASB 1994). The size of these amortization contributions depends on the dollar value of the funding deficit. Keeping the number of participants the same, since more mature pension funds have larger accrued liabilities, any reduction in the liability discount rate increases more the dollar amount of their reported liabilities and funding deficit. Thus, even if the funding ratio of more mature funds initially decreases less after a reduction in the liability discount rate, they face larger economic costs today from any reduction in the liability discount rate.

As catch-up contributions are borne only by the employer, i.e., by the state or local government entities (GASB 1994; Novy-Marx and Rauh 2014), this creates an economic burden for taxpayers or for employers (as well as potentially additional burdens for the participants in the future) servicing a more mature pension plan. Thus, U.S. public pension funds with a higher underfunding per participant have stronger incentives to maintain a higher liability discount rate, because that enables them to reduce the required contributions today and transfer the economic cost of underfunding to the future.

A natural question is whether the immediate negative economic effect of decreasing the liability discount rate on the sponsors of underfunded pension plans is mitigated by a lack of enforcement of the actual sponsor payment of the annual required contributions to the pension plan. Indeed, approximately 45 percent of state government systems paid less than the full required amount in 2009, 40 percent paid less than 90 percent of it, and 25 percent paid less than 80 percent of it (Novy-Marx and Rauh, 2014). However, if a pension fund does not receive the entire amount of annual required contributions from the sponsor (i.e., the employer), it faces a prolonged negative trend in its funding status in the years after the liability discount rate reduction, in addition to the initial reduction. This negative trend is steeper when the liability discount rate is lower, and moreover is again more pronounced for more mature pension funds.

The more negative trend in the funding ratio for more mature pension plans is caused by two factors. First, among mature funds, the outflows per participant for pension payments are larger than the inflows from normal cost contribution payments. Second, these pension plans continue to pay the entire promised amount of pensions to retirees, even though they are not fully funded. In contrast, younger public pension funds can stop or revert the negative trend using future normal contribution inflows and show an improving funding status after the initial reduction, while more mature U.S. public plans have fewer options to prevent the growing gap between their assets and promised liabilities.

We conclude that if mature pension funds reduce their discount rate, they face either higher annual required contribution payments today or a more strongly deteriorating funding status compared to younger funds. As a result, our test of the regulatory incentives hypothesis argues that within U.S. public pension funds, more mature funds have stronger incentives to maintain a higher discount rate.

A.I Actuarial assumptions used to measure the total pension liability

U.S. public pension funds typically use the "Entry Age Normal Cost Method" (EAN) to estimate their accrued liabilities and funding status (Novy-Marx and Rauh, 2014; see also (GASB 1994) for a description of available actuarial methods).[1] Under this actuarial method, pension liabilities are spread in a manner that produces smooth liability increases over time and stable level annual contributions as a percentage of pay. Basically, this method calculates what level contribution should be made each year as a percentage of pay from entry age (the age of hire) to retirement age, so that the accumulated amount is enough to pay the future projected benefits. The liabilities allocated to every year are called the "normal cost" and they correspond to the contribution payments for that year. Thus, the actuarial accrued liability for active members in any year is equal to the compounded sum of normal cost contributions allocated to prior years.

As an illustration to explain the EAN actuarial method, suppose that DB plan participants spend 30 years working and 20 years in retirement, that a pension fund pays a pension equal to $10 during each of the 20 years in retirement, and that the plan uses an expected rate of return on the assets and liability discount rate that are both equal to 8%. Under these assumptions, the pension plan needs to accumulate $98.18 in assets in year 30 in order to pay the $10/year pension benefit in the next 20 years, which is calculated using the formula for present value of an annuity:

$$PV_{Annuity} = 10\left[\frac{1}{0.08} - \frac{1}{0.08(1+0.08)^{20}}\right] = 98.18 \quad (1)$$

In order to accumulate $98.18 by year 30, the plan participants need to pay a contribution of $0.87

[1] For example, the 'Entry Age Normal Cost Method' is used by all large public pension funds, like CalPERS, CalSTRS, Washington, and Michigan, etc.

every year, assuming that these contributions grow at the expected rate of return. In particular, we calculate the contribution payment (C) using the formula for the future value of an annuity (which is equal to $98.18):

$$FV_{Annuity} = 98.18 = C\left[\frac{(1+0.08)^{30}-1}{0.08}\right] \tag{2}$$

$$C = 0.87 \tag{3}$$

Under the EAN valuation method, if the realized return on assets equals the liability discount rate (expected rate of return) every year, i.e., if the realized return on assets is 8% every year and thus equal to the liability discount rate, the funding ratio of this pension plan will always be equal to 100%. However, if the realized return on assets differs from the liability discount rate or if the pension plan does not receive sufficient contributions,[2] the pension plan can be either overfunded or underfunded.

A.II Stylized examples of three pension plans

Assuming that DB plan participants spend 30 years working and 20 years in retirement, we consider three stylized examples of pension funds that differ in the amount of time their participants have been working. One extreme case is Pension Fund C, where we assume that 100% of its participants have just recently retired. The other extreme case is Pension Fund A with 100% of the participants having just started working (we assume that the participants worked for one year such that the fund has some assets and liabilities). In addition to these two extreme cases, we consider Pension Fund B, which we assume consists entirely of participants around the middle of their working career, i.e., where all participants have worked for 15 years.

In these stylized examples, we further assume an inflation rate equal to 0% and a salary increase equal to 0%, while across all pension funds, the participants will receive a pension equal to $10 during each of the 20 years in retirement.

[2]This means that the pension plan receives contributions lower than the 'normal cost' contributions. One example is taking a contribution holiday—that is, a period of time when an employer and employees do not make payments into the pension fund, because they believe there is enough money in it to make necessary payments.

Table A.1: Three pension funds

Pension Fund A	100% of the participants have worked for only 1 year.
Pension Fund B	100% of the participants have worked for 15 years.
Pension Fund C	100% of the participants worked for 30 years and retire at the moment.

A.III The impact of changing the liability discount rate on the funding status

We start by assuming an expected rate of return and a discount rate of 8%. We also assume that all pension funds are initially underfunded with a funding ratio of 0.90. This assumption is similar to the situation among U.S. public pension funds (see Appendix Figure E.1). In Table A.2 Panel A, we include asset values that will result in a funding ratio of 0.90 for every pension fund. As discussed above, the asset value could differ from the liabilities if the realized return was lower than 8% or if the pension fund previously did not receive sufficient contributions. In Panel B, we consider what happens if the discount rate is reduced to 7%. We recalculate the actuarial value of accrued liabilities for every pension fund based on this change in the discount rate. The assets' value is not affected by the change in liability discount rate.

Table A.2: Changes in liability values and funding ratios due to changing the liability discount rate

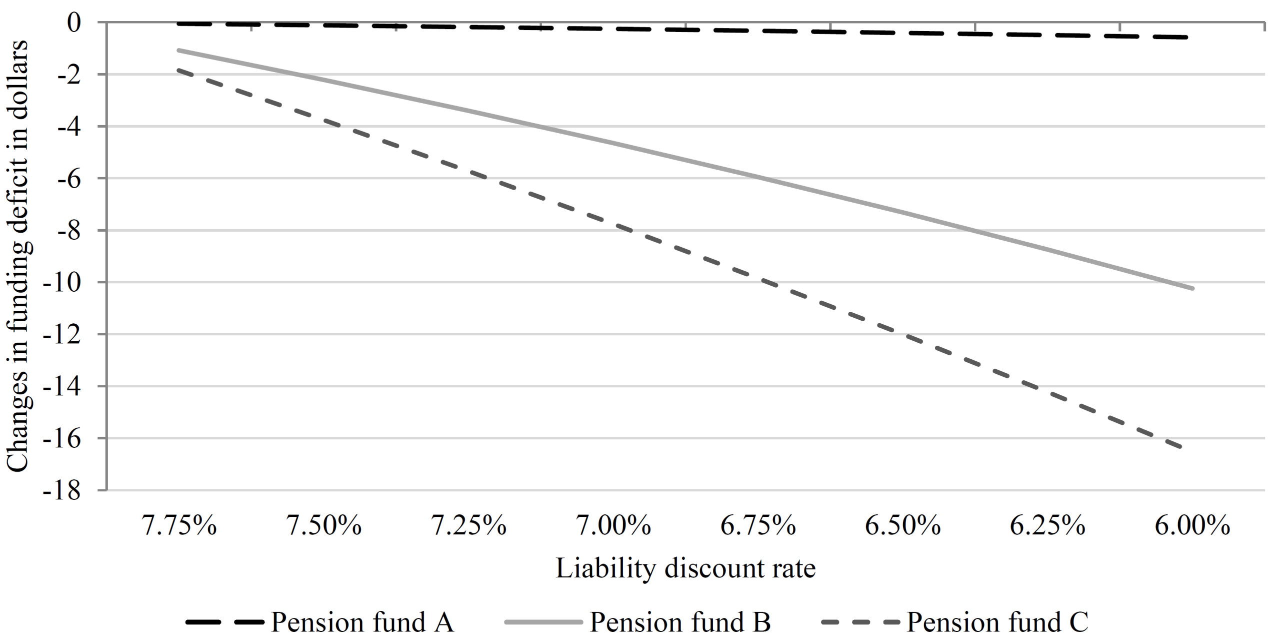
	Assets (A)	Liabilities (L)	Deficit (A - L)	Funding ratio (A/L)
Panel A: Liability discount rate = 8%				
Pension Fund A	\$0.78	\$0.87	-\$0.08	0.90
Pension Fund B	\$21.26	\$23.53	-\$2.27	0.90
Pension Fund C	\$88.70	\$98.18	-\$9.48	0.90
Panel B: Liability discount rate = 7%				
Pension Fund A	\$0.78	\$1.12	-\$0.34	0.70
Pension Fund B	\$21.26	\$28.18	-\$6.92	0.75
Pension Fund C	\$88.70	\$105.94	-\$17.24	0.84

Because Pension Fund C has the shortest-duration of liabilities, the value of its liabilities is less sensitive to the changes in the discount rate, while Pension Fund A's long-duration liabilities are most sensitive to the changes in discount rate. The liabilities of Fund A increase from \$0.87 to \$1.12, an increase of almost 29%, while the liabilities of Fund C increase from \$98.18 to \$105.94, a 7.9% change.

Therefore, the 'young' Pension Fund A experiences a drop in the funding ratio from 0.90 to 0.70, while the funding ratio of the 'mature' Pension Fund C decreases only to 0.84.

However, in absolute (dollar) terms the liabilities of Pension Fund C increase by $7.76, and the funding deficit of this pension plan automatically increases by the same amount. The funding deficits of Pension Funds A and B increase by a smaller amount. This illustrates that even though these three pension funds have the same number of participants, any reduction in the liability discount rate increases the dollar amount of the reported liabilities and funding deficit more for more mature pension plans, because a mature pension fund has a greater total liability since the participants have accrued liabilities for a longer period of time. Figure A.1 presents the changes in the funding deficit experienced by the three pension funds for different liability discount rates. The dollar amount of Fund C's reported funding deficit is the most affected one by any potential reduction in the discount rate. The dollar amount of the funding deficit is important because it serves as a starting point when calculating the additional catch-up contributions that should amortize this deficit.

Figure A.1: The impact of changing the liability discount rate on the funding deficit



A.IV The impact of changing the discount rate on the required contributions

In this analysis, we consider how the contribution payments will develop during the ten years after the initial reduction in the liability discount rate. The annual required contributions consist of both normal contributions for benefits attributable to the current year of service and catch-up (deficit-reduction) contributions in case the pension fund is underfunded (GASB 1994). Both components of the annual required contribution payments are affected by the discount rate changes.

First, we examine the changes in the normal cost contribution payments. Under the EAN actuarial method the new contribution inflows should equal the new accrued liabilities, so that the new accrued liabilities enter the calculation as being fully funded. In order to maintain that equality, changing the discount rate will increase the normal cost contributions. Under this method, the contributions are calculated like an annuity that needs to be paid every year in order to cumulate the value needed at the retirement age (which in our example is set equal to the present value of $10/year over 20 years). Table A.3 presents the normal cost contribution payment corresponding to different discount rates.[3]

Table A.3: The relation between the discount rate and the normal cost contributions

Discount rate	Normal cost contribution per year
9%	$0.67
8%	$0.87
7%	$1.12
6%	$1.45

Thus, if pension funds change their liability discount rate, their contribution inflows in the following years will also automatically change, if they have active participants who are still working. For instance, the normal contribution payments of Pension Funds A and B will increase from $0.87 to $1.12 if they adopt a lower discount rate of 7% instead of the current discount rate of 8%. Pension Fund C does not have active members, as all of its participants entered retirement, and thus its normal cost contributions are equal to zero irrespective of the liability discount rate.

Second, we examine the changes in catch-up or deficit-reduction contributions. Among U.S. public

[3] To calculate these values, we use the same formula for contribution payments (C) as in equation (2).

pension funds, the employer (i.e., state, county or city sponsoring the pension fund) needs to pay an additional catch-up contribution to cover already accrued but unfunded liabilities. Current regulations allow them to amortize these catch-up contributions over the next 30 years (GASB 1994). In the stylized examples below we assume that the amortization period is 20 years, because participants spend 20 years in retirement. The size of these amortization payments depends on the dollar amount of the funding deficit.

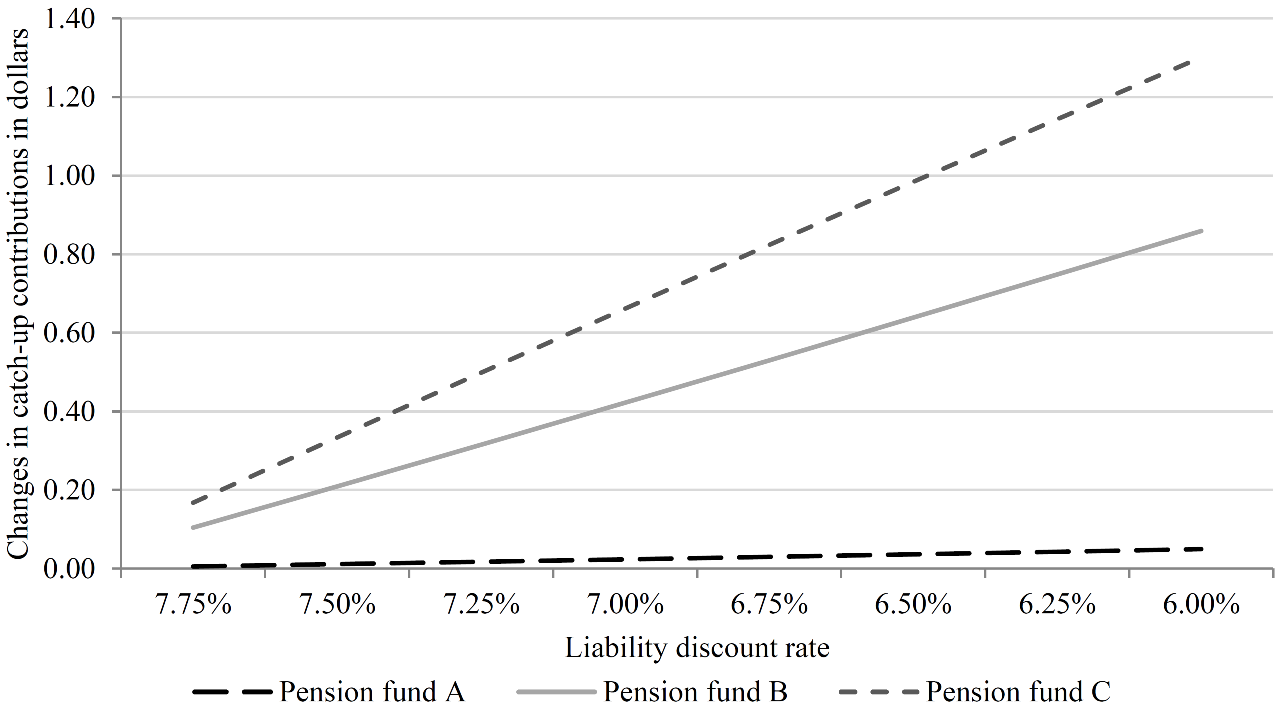
Table A.4 presents the catch-up contributions that should be paid by all three pension funds in year *t+1* based on their funding status in year *t*. In Panel A, with a discount rate equal to 8%, even though the funding ratio is the same for all three pension plans, Fund C has to pay the largest catch-up contributions because it has the largest deficit in dollar terms. Reducing the discount rate increases the catch-up contributions for all three pension plans. In dollar terms, the required deficit-reduction contributions increase by $0.66 for Fund C, $0.42 for Fund B and $0.02 for Fund A.

Table A.4: The relation between discount rate and catch-up contribution payments

	Assets (A)	Liabilities (L)	Deficit (A - L)	Funding ratio	Catch-up contributions
Panel A: Liability discount rate = 8%					
Pension fund A	$0.78	$0.87	-$0.08	0.90	$0.01
Pension fund B	$21.26	$23.53	-$2.27	0.90	$0.23
Pension fund C	$88.70	$98.18	-$9.48	0.90	$0.97
Panel B: Liability discount rate = 7%					
Pension fund A	$0.78	$1.12	-$0.34	0.70	$0.03
Pension fund B	$21.26	$28.18	-$6.92	0.75	$0.65
Pension fund C	$88.70	$105.94	-$17.24	0.84	$1.63

Figure A.2 presents the potential changes in the catch-up contribution payments for the three pension funds in year *t+1* conditional on the liability discount rate choice. One year after the discount rate reduction, Fund C always faces larger increases in the contributions required to amortize the total unfunded accrued liability. In dollar terms, the catch-up contribution payments of Pension Funds A and B are less affected. This figure shows that mature pension funds face larger economic costs per participant after reducing their liability discount rate. Since the catch-up contributions should be paid during the entire amortization period, this conclusion holds not only for the first year, but also for the entire period after the initial reduction in the discount rate.

Figure A.2: The impact of changing the liability discount rate on the catch-up contributions



As pointed out at the beginning of this section, the annual required contributions (ARC) represent a sum of the normal cost contributions and the deficit reduction contributions. Table A.5 presents the trend in ARC in the next ten years. Again, we compare a scenario of maintaining a liability discount rate of 8% and a scenario of using a lower liability discount rate of 7%. In Table A.5, NC refers to normal cost contributions, while CC represents catch-up contributions. This analysis assumes that the realized return on assets is every year equal to the liability discount rate.

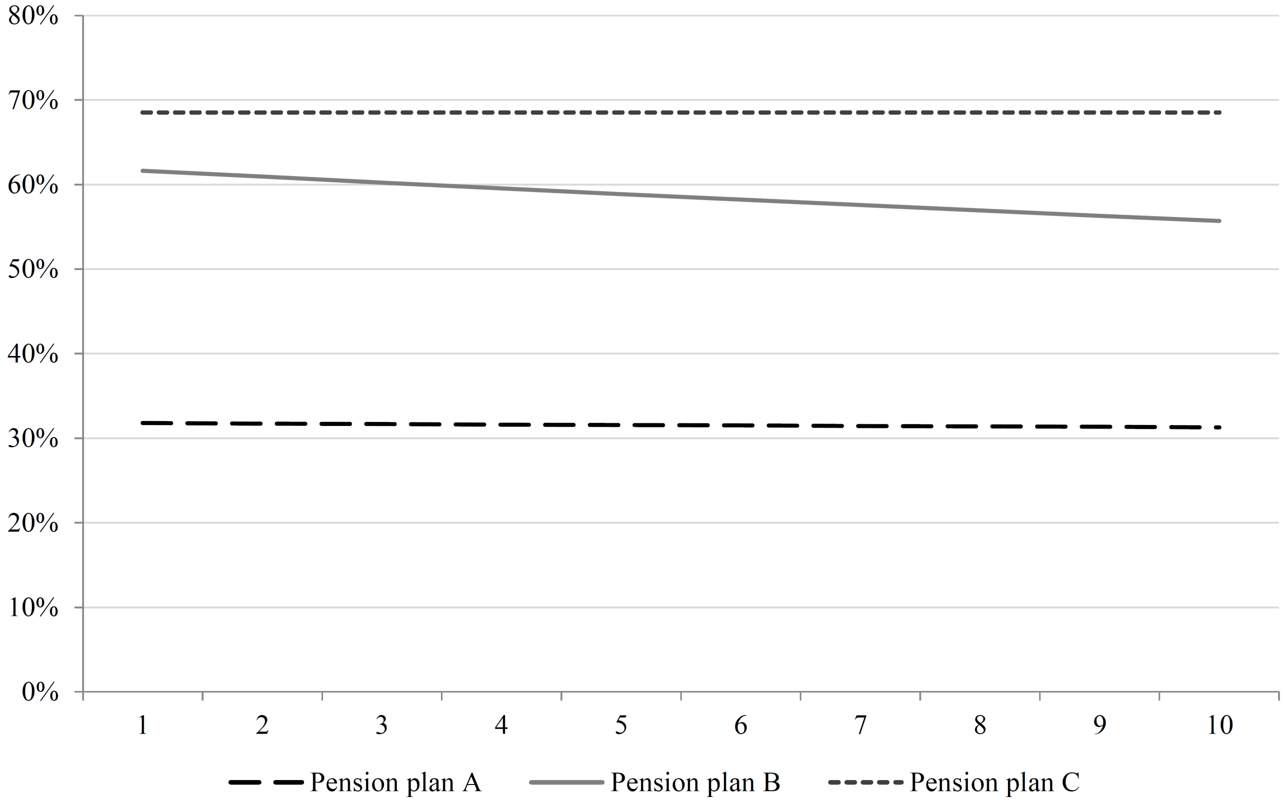
The annual required contribution payments increase for all three pension funds if the liability discount rate is lowered from 8% to 7%. For Fund A, the major increase pertains to the normal contributions for newly accrued pensions. Fund B experiences an increase in both normal cost and deficit reduction catch-up contributions. Fund C faces only an increase in the deficit-reduction catch-up contributions. Importantly, the catch-up contributions for Pension Funds A and B decline over time (though this effect is minor for Fund A, and not significant due to rounding), because the new higher normal cost contribution payments equal the amount of newly accrued liabilities allocated to that year, i.e., they enter the valuation as if they are fully funded. Mixing new fully funded liabilities with the past underfunded liabilities results in an upward (improving) trend in the funding ratio. Therefore, the gap between the assets and liabilities of younger funds is shrinking over time, which gradually lowers their deficit-reduction contributions.

Table A.5: Trend in annual required contribution (ARC)

Year	Pension Fund A			Pension Fund B			Pension Fund C		
	NC	CC	ARC	NC	CC	ARC	NC	CC	ARC
Panel A: Liability discount rate = 8%									
1	0.87	0.01	0.88	0.87	0.23	1.10	0	0.97	0.97
2	0.87	0.01	0.88	0.87	0.23	1.09	0	0.97	0.97
3	0.87	0.01	0.87	0.87	0.22	1.09	0	0.97	0.97
4	0.87	0.01	0.87	0.87	0.22	1.08	0	0.97	0.97
5	0.87	0.01	0.87	0.87	0.21	1.08	0	0.97	0.97
6	0.87	0.01	0.87	0.87	0.21	1.07	0	0.97	0.97
7	0.87	0.01	0.87	0.87	0.20	1.07	0	0.97	0.97
8	0.87	0.01	0.87	0.87	0.20	1.06	0	0.97	0.97
9	0.87	0.01	0.87	0.87	0.19	1.06	0	0.97	0.97
10	0.87	0.01	0.87	0.87	0.19	1.06	0	0.97	0.97
Panel B: Liability discount rate = 7%									
1	1.12	0.03	1.15	1.12	0.65	1.77	0	1.63	1.63
2	1.12	0.03	1.15	1.12	0.64	1.76	0	1.63	1.63
3	1.12	0.03	1.15	1.12	0.62	1.74	0	1.63	1.63
4	1.12	0.03	1.15	1.12	0.61	1.73	0	1.63	1.63
5	1.12	0.03	1.15	1.12	0.59	1.71	0	1.63	1.63
6	1.12	0.03	1.15	1.12	0.58	1.70	0	1.63	1.63
7	1.12	0.03	1.15	1.12	0.56	1.68	0	1.63	1.63
8	1.12	0.03	1.15	1.12	0.55	1.67	0	1.63	1.63
9	1.12	0.03	1.15	1.12	0.54	1.66	0	1.63	1.63
10	1.12	0.03	1.15	1.12	0.52	1.64	0	1.63	1.63

Figure A.3 shows the percentage change in annual required contribution payments for all three pension funds that results from reducing the discount rate from 8% to 7%. Even though the liabilities in Pension Fund C have the shortest duration and even though this plan experiences the smallest initial change in the funding ratio due to the discount rate reduction, it faces the highest percentage increase in the annual required contribution payments. Funds A and B experience larger initial changes in the funding ratio due to the discount rate reduction, but their funding gap is still smaller, and thus their

Figure A.3: **Percentage change in annual required contribution payments**



contribution payments are less affected.

Overall, these stylized scenarios illustrate that reducing the liability discount rate creates larger immediate economic costs for mature pension plans like Fund C. Therefore, lowering the liability discount rate has a much bigger immediate effect on the taxpayers, employers and plan participants' contributions in Fund C than in Fund A. Importantly, the catch-up contributions are economically more visible and costly, because they are not planned (expected) normal contributions and because they are fully borne by the employer (or the taxpayers), while the normal contributions are typically split between the employer and employees (GASB 1994; Novy-Marx and Rauh 2014).

A.V The impact of not paying the required contribution on the funding ratio

A possible counter-argument to our preceding analysis is that the economic effect on taxpayers and employers (i.e., government entities) for mature pension plans (i.e., Fund C in our stylized examples) is exaggerated because the sponsors of pension funds are not always forced to pay the full amount of the annual required contributions. Indeed, approximately 45 percent of U.S. state retirement systems paid less than the full required amount in 2009 and the mean system that did not pay the full required contribution paid only 73 percent of it (Novy-Marx and Rauh, 2014). Mitchell and Smith (1994) document that states sensitive to fiscal pressure (proxied with unusually high unemployment rates) do not pay fully the required pension contributions. However, if mature U.S. public pension funds do not pay the full amount of the annual required contribution, then they face a prolonged negative trend in their funding status in the years after the discount rate reduction, in addition to the initial reduction. This negative trend is steeper when the liability discount rate is lower. Most importantly, this negative trend is significantly more pronounced for more mature pension funds.

Table A.6 displays how the funding ratios of the three pension funds will develop in the next ten years if the liability discount rate is equal to 8% or 7% (and assuming that the realized return on assets equals the liability discount rate). In this case, we assume that none of the three pension funds pay the required catch-up contributions. Funds A and B continue to pay the normal cost contributions of \$0.87 and \$1.12, respectively, while Fund C does not have to pay normal cost contributions. In Table A.6, A, B and C refer to the funding ratio of the corresponding pension fund.

Table A.6: Funding ratio after persistent non-payment of catch-up contributions

Year	Discount rate = 8%			Discount rate = 7%		
	A	B	C	A	B	C
0	0.90	0.90	0.90	0.70	0.75	0.84
1	0.95	0.91	0.89	0.84	0.76	0.82
2	0.97	0.91	0.88	0.89	0.77	0.80
3	0.97	0.91	0.87	0.92	0.78	0.78
4	0.98	0.91	0.85	0.93	0.78	0.76
5	0.98	0.92	0.84	0.94	0.79	0.73
6	0.98	0.92	0.82	0.95	0.79	0.70
7	0.98	0.92	0.79	0.95	0.80	0.67
8	0.99	0.92	0.77	0.96	0.80	0.63
9	0.99	0.92	0.73	0.96	0.80	0.58
10	0.99	0.92	0.69	0.96	0.81	0.52

Immediately after the reduction in the liability discount rate from 8% to 7%, Pension Fund C seems to be least affected by the change in the liability discount rate, but its funding ratio deteriorates quickly in the following years. At the same time, the funding status of the other two pension plans improves due to the increased 'normal cost' contributions. Even when the liability discount rate equals 7%, the mature Fund C is the worst funded pension plan in year 4 already. The funding status of Fund C decreases quickly, because this plan does not receive any normal (and thus fully funded) contribution inflows and starts paying out pensions of $10/year to retired plan participants in year 1.

In general, the more negative trend for more mature pension plans is caused by two factors. First, among more mature funds, the outflows for pension payments are larger than the inflows from normal cost contribution payments. Second, these more mature pension funds continue to pay the entire promised amount of pensions, even though they are not fully funded. Younger U.S. public pension funds can stop or revert the negative trend using the future normal contribution inflows and show an improving funding status after the initial reduction, while more mature U.S. public funds have fewer options to prevent the growing gap between their assets and promised liabilities.

In conclusion, not paying the required catch-up contributions more negatively affects the funding ratio of the more mature Fund C. Funds A and B receive higher normal contribution payments equal to the amount of newly accrued liabilities that year. Mixing new fully funded liabilities with the past underfunded liabilities results in an upward (i.e., improving) trend in their funding ratio. Therefore, the gap between the assets and liabilities of younger funds is shrinking over time, even if these plans do not pay the required deficit-reduction catch-up contributions. On the other hand, Fund C would have to disclose a rapidly deteriorating funding status if it would not pay the catch-up contributions.

A.VI The impact of lower investment returns on the required contributions

The scenarios above assume that pension funds obtain an investment return of their assets equal to the liability discount rate. In this section, we consider how the contribution rates of the three pension funds will develop in the next ten years if the realized return on assets equals only 5.5%, which is significantly lower than the assumed liability discount rate of 7%. We further assume that the normal contributions payment is $1.12 and pension funds fully pay the required catch-up contributions. In Table A.7, NC refers to normal cost contributions, while CC represents catch-up contributions. The total annual required contributions (ARC) are equal to the sum of these two components.

Table A.7: Contributions over time assuming realized asset returns of 5.5%/year

Year	Pension Fund A			Pension Fund B			Pension Fund C		
	NC	CC	ARC	NC	CC	ARC	NC	CC	ARC
1	1.12	0.03	1.15	1.12	0.65	1.77	0	1.63	1.63
2	1.12	0.03	1.15	1.12	0.67	1.79	0	1.76	1.76
3	1.12	0.03	1.16	1.12	0.69	1.81	0	1.88	1.88
4	1.12	0.04	1.16	1.12	0.71	1.83	0	2.01	2.01
5	1.12	0.04	1.17	1.12	0.73	1.86	0	2.13	2.13
6	1.12	0.05	1.17	1.12	0.76	1.89	0	2.25	2.25
7	1.12	0.06	1.18	1.12	0.80	1.92	0	2.38	2.38
8	1.12	0.07	1.19	1.12	0.84	1.96	0	2.50	2.50
9	1.12	0.09	1.21	1.12	0.88	2.01	0	2.61	2.61
10	1.12	0.10	1.22	1.12	0.93	2.06	0	2.73	2.73

Obtaining an investment return on the assets lower than the (assumed) liability discount rate negatively influences the funding deficit of all three pension funds. This negative impact translates into higher catch-up contributions, and consequently, higher annual required contributions. The more mature Pension Fund C is most affected by the lower realized investment returns and its annual required contributions increase from $1.63 in year 1 to $2.73 in year 10. Overall, this analysis shows that more mature pension funds are more affected by experiencing investment returns on their assets that are lower than the liability discount rate.

A.VII Conclusion

Reducing the liability discount rate negatively affects the funding status and required contribution payments of all pension funds. The negative effects are more pronounced among more mature pension funds. There are three measures that pension funds can take in order to overcome their funding problems, all of which are relatively more challenging for mature funds.

First, pension funds can pay deficit reduction catch-up contributions. Among U.S. public pension funds, the employer (i.e., the state, county or city) needs to pay an additional catch-up contribution to cover the already accrued, but unfunded liabilities over the next 30 years. The size of these amortization payments depends on the underfunding amount and is larger for more mature pension plans. Therefore, more mature pension funds have a stronger incentive to maintain a higher discount rate and transfer the economic costs of underfunding to the future.

Second, if the employer cannot bear the higher required contribution payments, mature pension plans can consider cutting pension benefits. However, implementing reductions in pension benefits that are already accrued is politically costly and legally difficult. Some states (like Rhode Island and New Jersey) have reduced and restructured pension benefits by making the cost-of-living adjustments (i.e., inflation adjustments) conditional on the funding status. Still, their restructuring does not cancel past inflation adjustments and does not affect already accrued benefits, which are generally strongly protected by law. Therefore, participant elected and ex officio trustees of more mature U.S. public funds have stronger incentives to postpone potential restructuring measures and receive inflation compensations as long as possible. They can postpone restructuring by maintaining a higher discount rate and not reporting a deteriorating funding status.

Third, more mature plans can also try to obtain a higher return on their assets, e.g. by taking more risk. If the realized returns on their assets are higher than the expected rate of return (discount rate), then their funding status will improve. However, investment performance is volatile and we find no evidence that more mature pension funds possess more asset management skill.

Overall, our regulatory incentives hypothesis is motivated by the larger increase in required contribution payments of more mature pension funds after they decrease their liability discount rate. The stronger deteriorating trend in the funding status of more mature pension funds in the years after they decrease their liability discount rate is another reason why these funds may more strongly resist a potential reduction in the liability discount rate. As a result, more mature pension funds have a stronger incentive to maintain a higher liability discount rate.

Appendix B: Percentage allocated to risky assets

This appendix contains details and supplemental analysis on the percentage allocated to risky assets by pension funds. Table B.1 presents the mean percentage allocated to risky assets for every year during the 1993–2012 period. This table also compares actual with strategic asset allocation policy. The descriptive statistics indicate that U.S. public pension funds increase their allocation to risky asset over time, while other pension funds do not have an increasing trend.

Our regulatory incentives hypothesis argues that the regulatory link between the liability discount rate and the expected rate of return on assets gives U.S. public funds an incentive to increase their strategic allocation to risky assets with higher expected returns in order to justify a higher discount rate and, as a consequence, lower the reported value of the liabilities. One test of this hypothesis posits that within U.S. pension funds, more mature funds have stronger incentives to maintain a higher liability discount rate. Maintaining a higher discount rate enables them to reduce the required contributions today and transfer the economic cost of underfunding to the future.

Our identification is based on comparing U.S. public pension funds with public pension funds from other countries and with U.S. private pension funds. Table 3 presents the triple interaction term, which should be significant if U.S. public pension funds invest differently from all other pension funds. The interaction term *%Retired* × *Public* measures the relation between maturity and allocation to risky assets among all public plans. This term should be significant if fund type determines the allocation to risky assets, regardless of regulatory differences. The interaction term *%Retired* × *U.S.* measures the relation between maturity and allocation to risky assets among all U.S. plans. This term should be significant if cross-country differences determine the allocation to risky assets, regardless of regulatory differences and fund type. The triple interaction term *%Retired* × *Public* × *U.S.* measures the relation between maturity and percentage allocated to risky assets only among U.S. public pension funds. This term is significant in Table 3, indicating that U.S. public plans invest in a different way and the difference in their asset allocation cannot be attributed to country or fund type effects. Thus, we attribute the differences in the asset allocation decisions to their distinct regulatory standards.

In the robustness results, we reduce the number of interaction terms and focus on two subsamples:

(i) the subsample of all U.S. pension funds; (ii) the subsample of all public pension funds.

In Table B.2, we perform a cross-type analysis of the relation between fund maturity and focus only on the subsample of U.S. pension funds. This test shows that our results are not determined by differences across countries and the magnitude of our findings is even larger when we reduce the number of interaction terms. We document that fund maturity of U.S. private funds is negatively related to their allocation to risky assets, while among U.S. public funds there is a positive relation between fund maturity and allocation to risky assets. Moreover, the relation between the lagged treasury yield and allocation to risky assets is significantly negative only for U.S. public pension funds, and not for U.S. corporate plans.

We also perform a separate analysis only on the subsample of public pension funds, thus excluding all private funds. Table B.3 presents the results and indicates that U.S. public pension funds make different asset allocation decisions than public pension funds from Canada and Europe. The base results in this table refer to U.S. public plans and we include interaction terms for European and Canadian plans, because the samples from other countries are small. Namely, we have only 56 Canadian public funds (487 observations) and 9 European public funds (42 observations). Nevertheless, our results indicate that the positive relation between allocation to risky assets and fund maturity is present only among U.S. public pension funds. Similarly, the relation between the lagged treasury yield and allocation to risky assets is significantly negative only for U.S. public pension funds.

As an additional robustness check, we construct a matched sample of pension funds. We split the sample into two parts: U.S. public pension funds and all other pension funds. We match each U.S. public pension fund with another fund from the control sample separately for each year based on two variables: fund size and the percentage of retired members. Table B.4 presents the results. In this analysis we cannot use fund fixed effects because the control sample does not include the same pension funds every year. The results confirm that mature U.S. public pension funds invest more in risky assets.

In the paper, we use the strategic asset allocation weights when calculating the riskiness of the investment policy. We define the percentage allocated to risky assets as a sum of the strategic allocation weights to equity, alternative asset classes, and risky fixed income investments. We classify allocations to high yield, emerging market debt and mortgages as risky fixed income investments. Importantly, our results are robust to calculating the percentage allocated to risky assets in two different ways: (1) removing the risky fixed income assets from the risky assets; and (2) calculating the percentage allocated to risky assets based on the actual asset allocation weights instead of the strategic asset allocation weights. Table B.5 reports our main results using the percentage allocated to risky asset based on the actual asset allocation policy as a dependent variable. In Table B.6, we exclude the allocation to risky fixed income assets, like emerging markets debt, high yield securities and mortgages, from the definition of risky assets. Overall, the results in these two tables are very similar to Table 3 in the paper.

Further, in Table B.7, we disaggregate the risky assets into equity, alternative assets and risky fixed income assets. Alternative assets, like private equity, real estate and hedge funds, are considered to be riskier and less liquid than public equity and fixed income. Hence, by increasing the allocation to alternative assets, U.S. public pension funds could declare higher expected return on assets. We document that more mature U.S. public funds invest more in all three groups of risky assets, but the relative increases in their allocation to alternative assets are economically larger.

We also extend our analysis by controlling for past net performance or past net benchmark-adjusted returns in Table B.8. Our results indicate that pension funds do not modify their strategic asset allocation policy in response to lagged returns. Pension funds would have more incentives to increase the allocation to risky assets when the funding ratio is low. There are smaller incentives to invest more in risky assets when the funding ratio is high even if the pension fund experiences negative returns. Hence, we also test whether pension fund strategic allocation to risky assets responds more to the past performance in the later sample period, from 2001 to 2012, when the funding ratios were on average lower. Table B.8 columns (5) and (6) show that even in this later sample period the lagged net benchmark-adjusted returns are not significantly related to the percentage allocated to risky assets.

In Table B.9, we study the regional differences in allocation to risky assets. The regional dummy variables for Canada and Europe are negative and significant, indicating that Canadian and European pension funds invest less in risky assets than U.S. pension funds. Controlling for maturity and fund size, U.S. plans allocate around 7 percent more to risky assets than Canadian plans, and 12 percent more than European plans. Additionally, in column (5), we also observe that the *Public* × *U.S.* variable is not significant. This result indicates that during our sample period on average U.S. public pension funds invest similar percentage of their asset in risky asset classes as U.S. corporate pension funds. However, the relation with the percentage of retired members is opposite in the two subsamples.

Table B.1: **Summary statistics: Percentage allocated to risky assets**

This table provides descriptive statistics for pension fund asset allocation during the 1993–2012 period. %*ActRisky* shows the average percentage allocation to risky assets based on the actual asset allocation policy, whereas %*PolRisky* shows the average percentage allocation to risky assets based on the strategic asset allocation policy. The risky assets include allocations to equity, alternative asset classes (i.e., hedge funds, private equity, and real estate), and risky fixed income assets. We show the averages for all funds (U.S., Canadian and European pension plans) and separately for U.S. public and U.S. private pension funds.

	All funds		**U.S. public**		**U.S. private**	
Year	%ActRisky	%PolRisky	%ActRisky	%PolRisky	%ActRisky	%PolRisky
1993	0.619	0.615	0.544	0.565	0.678	0.665
1994	0.610	0.609	0.557	0.587	0.672	0.668
1995	0.619	0.612	0.583	0.593	0.683	0.677
1996	0.630	0.617	0.590	0.588	0.686	0.672
1997	0.642	0.634	0.621	0.626	0.699	0.691
1998	0.646	0.644	0.641	0.646	0.704	0.700
1999	0.665	0.646	0.669	0.655	0.721	0.705
2000	0.660	0.655	0.656	0.656	0.721	0.722
2001	0.658	0.666	0.658	0.675	0.707	0.718
2002	0.651	0.664	0.651	0.672	0.693	0.713
2003	0.672	0.674	0.692	0.693	0.723	0.726
2004	0.694	0.684	0.724	0.709	0.741	0.729
2005	0.692	0.678	0.729	0.718	0.742	0.723
2006	0.696	0.675	0.745	0.727	0.731	0.708
2007	0.698	0.685	0.740	0.731	0.716	0.698
2008	0.645	0.662	0.712	0.728	0.670	0.681
2009	0.637	0.650	0.707	0.730	0.646	0.654
2010	0.658	0.651	0.734	0.728	0.659	0.648
2011	0.635	0.632	0.749	0.739	0.632	0.625
2012	0.638	0.637	0.746	0.745	0.617	0.617

Table B.2: **Regressions: Percentage allocated to risky assets by U.S. funds**

Robustness check of Table 3: cross-type analysis. In this table we analyze only the subsample of U.S. pension funds.

In this table, we estimate a panel model. The dependent variable is the percentage allocation to risky assets based on the strategic asset allocation of U.S. pension funds. Independent variables include *%Retired*, the percentage of retired members from total pension fund members; *%Retired* × *Public*, an interaction term capturing the percentage of retired members among public funds; $Yield_{t-1}$, the Treasury yield in the previous year; $Yield_{t-1}$ × *Public*, an interaction term capturing the effect of the previous year's Treasury yield on public funds; *Fund size*, the logarithm of total pension fund assets; *Inflation protection*, a dummy variable taking a value of one if a fund provides a contractual inflation protection; and *Public*, a dummy variable taking a value of one if a pension fund is public. Where indicated, we include year dummies and pension fund fixed effects. We independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)
Dependent variable: Percentage allocated to risky assets					
%Retired	-0.178***	-0.182***	-0.159***	-0.107***	-0.098***
	[0.042]	[0.041]	[0.028]	[0.038]	[0.028]
%Retired × Public		0.826***	0.474***		
		[0.184]	[0.121]		
Yield_{t-1}	0.005	0.005	0.019***	0.013**	0.026***
	[0.005]	[0.006]	[0.001]	[0.006]	[0.002]
Yield_{t-1} × Public				-0.044***	-0.046***
				[0.007]	[0.007]
Fund size	0.020	0.002	0.008***	0.010	0.004
	[0.021]	[0.020]	[0.003]	[0.019]	[0.003]
Inflation protection			0.023**		0.024**
			[0.010]		[0.011]
Public			-0.203***		0.199***
			[0.051]		[0.033]
Year FE	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	No	Yes	No
Double-clustering	Yes	Yes	Yes	Yes	Yes
Observations	3,382	3,382	3,355	3,382	3,355
R^2	0.684	0.707	0.130	0.716	0.145

Table B.3: **Regressions: Percentage allocated to risky assets only by public funds**

Robustness check of Table 3: cross-county analysis. In this table we analyze only the subsample of public pension funds.

In this table, we estimate a panel model. The dependent variable is the percentage allocation to risky assets based on the strategic asset allocation of public pension funds (private funds are excluded). Independent variables include *%Retired*, the percentage of retired members from total pension fund members; *%Retired* × *Canada*, an interaction term capturing the percentage of retired members among Canadian public funds; *%Retired* × *Europe*, an interaction term capturing the percentage of retired members among European public funds; $Yield_{t-1}$, the Treasury yield in the previous year; $Yield_{t-1}$ × *Canada*, an interaction term capturing the effect of the previous year's Treasury yield on Canadian public funds; $Yield_{t-1}$ × *Europe*, an interaction term capturing the effect of the previous year's Treasury yield on European public funds; *Fund size*, the logarithm of total pension fund assets; *Inflation protection*, a dummy variable taking a value of one if a fund provides a contractual inflation protection; *Canada* and *Europe*, regional dummy variables. Where indicated, we include year dummies and pension fund fixed effects. We independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)
Dependent variable: Percentage allocated to risky assets					
%Retired	0.095	0.163*	0.196*	0.043	0.010
	[0.059]	[0.086]	[0.103]	[0.062]	[0.055]
%Retired × Canada		-0.149	-0.261**		
		[0.146]	[0.106]		
%Retired × Europe		-0.777***	-0.172		
		[0.148]	[0.456]		
$Yield_{t-1}$	-0.018***	0.006	0.011	-0.025***	-0.040***
	[0.005]	[0.009]	[0.013]	[0.005]	[0.006]
$Yield_{t-1}$ × Canada				0.021***	0.015**
				[0.006]	[0.007]
$Yield_{t-1}$ × Europe				0.052**	0.036
				[0.021]	[0.031]
Fund size	0.087***	0.020	0.010***	0.095***	0.010***
	[0.017]	[0.023]	[0.004]	[0.016]	[0.003]
Inflation protection			0.033***		0.035***
			[0.012]		[0.013]
Canada			0.026		-0.130***
			[0.043]		[0.038]
Europe			-0.091		-0.297**
			[0.171]		[0.137]
Year FE	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	No	Yes	No
Double-clustering	Yes	Yes	Yes	Yes	Yes
Observations	1,894	1,894	1,893	1,894	1,893
R^2	0.770	0.796	0.343	0.778	0.281

Table B.4: **Regressions: Percentage allocated to risky assets**

Robustness check of Table 3: analysis based on a matched subsample. We match each U.S. public pension fund with another fund from the control sample separately for each year based on two variables: fund size and the percentage of retired members.

In this table, we estimate a panel model. The dependent variable is the percentage allocation to risky assets based on the strategic asset allocation of pension funds. Independent variables include *%Retired*, the percentage of retired members from total pension fund members; *%Retired* × *Public* × *U.S.*, an interaction term capturing the percentage of retired members among U.S. public funds; $Yield_{t-1}$, the Treasury yield in the previous year; $Yield_{t-1}$ × *Public* × *U.S.*, an interaction term capturing the effect of the previous year's Treasury yield on U.S. public funds; *Fund size*, the logarithm of total pension fund assets; *Inflation protection*, a dummy variable taking a value of one if a fund provides a contractual inflation protection; *Public* × *U.S.*, a dummy variable for U.S. public funds; and *U.S.*, regional dummy variable. We include year dummies and independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)
Dependent variable: Percentage allocated to risky assets			
%Retired	0.094	-0.053	0.067
	[0.061]	[0.058]	[0.057]
%Retired × Public × U.S.		0.301**	
		[0.119]	
Yield_{t-1}	0.024**	0.024**	0.022**
	[0.010]	[0.010]	[0.011]
Yield_{t-1} × Public × U.S.			-0.029***
			[0.007]
Fund size	0.007**	0.008***	0.007**
	[0.003]	[0.003]	[0.003]
Inflation protection	0.022**	0.033***	0.032***
	[0.010]	[0.010]	[0.010]
Public × U.S.		-0.145***	0.112***
		[0.050]	[0.035]
U.S.	0.082***	0.117***	0.106***
	[0.012]	[0.017]	[0.016]
Year FE	Yes	Yes	Yes
Double-clustering	Yes	Yes	Yes
Observations	2,725	2,725	2,725
R^2	0.191	0.221	0.231

Table B.5: **Regressions: Percentage allocated to risky assets**

Robustness check of Table 3: the dependent variable, percentage allocated to risky assets, is based on the actual asset allocation, not the strategic assets allocation policy.

In this table, we estimate a panel model. The dependent variable is the percentage allocated to risky assets based on the actual asset allocation of pension funds. The risky assets include allocations to equity, alternative asset classes, and risky fixed income. Independent variables include *%Retired*, the percentage of retired members from total pension fund members; *%Retired* × *Public*, an interaction term capturing the percentage of retired members among public funds; *%Retired* × *U.S.*, an interaction term capturing the percentage of retired members among U.S. pension funds; *%Retired* × *Public* × *U.S.*, an interaction term capturing the percentage of retired members among U.S. public funds; $Yield_{t-1}$, the Treasury yield in the previous year; $Yield_{t-1}$ × *Public*, an interaction term capturing the effect of the previous year's Treasury yield on public funds; $Yield_{t-1}$ × *U.S.*, an interaction term capturing the effect of the previous year's Treasury yield on U.S. funds; and $Yield_{t-1}$ × *Public* × *U.S.*, an interaction term capturing the effect of the previous year's Treasury yield on U.S. public funds; *Fund size*, the logarithm of total pension fund assets; *Inflation protection*, a dummy variable taking a value of one if a fund provides a contractual inflation protection; *Public*, a dummy variable taking a value of one if a pension fund is public; *Public* × *U.S.*, a dummy variable for U.S. public funds; and *U.S.*, a regional dummy variable. Where indicated, we include year dummies and fund fixed effects. We independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Percentage allocated to risky assets						
%Retired	-0.149***	-0.156***	-0.109**	-0.073**	-0.106***	-0.090***	-0.072***
	[0.036]	[0.035]	[0.048]	[0.033]	[0.033]	[0.031]	[0.020]
%Retired × Public × U.S.		0.826***	0.805***	0.476***			
		[0.159]	[0.175]	[0.129]			
%Retired × Public			0.042	0.022			
			[0.076]	[0.065]			
%Retired × U.S.			-0.066	-0.069*			
			[0.060]	[0.040]			
Yield_{t-1}	0.003	-0.003	-0.000	0.003	-0.005	0.003	0.007
	[0.006]	[0.006]	[0.005]	[0.008]	[0.006]	[0.005]	[0.007]
Yield_{t-1} × Public × U.S.					-0.041***	-0.038***	-0.024***
					[0.006]	[0.008]	[0.008]
Yield_{t-1} × Public						-0.011**	-0.028***
						[0.006]	[0.006]
Yield_{t-1} × U.S.						0.013**	0.006
						[0.006]	[0.005]
Fund size	0.007	0.007	0.005	0.007***	0.017	0.007	0.005**
	[0.017]	[0.016]	[0.016]	[0.002]	[0.016]	[0.015]	[0.002]
Inflation protection				0.016**			0.017**
				[0.007]			[0.007]
Public × U.S.				-0.190***			0.092**
				[0.051]			[0.043]
Public				-0.023			0.131***
				[0.030]			[0.034]
U.S.				0.118***			0.059**
				[0.019]			[0.028]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	No	Yes	Yes	No
Double-clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,510	5,510	5,510	5,463	5,510	5,510	5,463
R^2	0.740	0.756	0.756	0.198	0.762	0.767	0.222

Table B.6: **Regressions: Percentage allocated to risky assets**

Robustness check of Table 3: the dependent variable, percentage allocated to risky assets, excludes any investments in fixed income. Our typical calculation of the percentage allocated to risky assets includes investments in high yield, emerging market debt and mortgages.

In this table, we estimate a panel model. The dependent variable is the percentage allocated to risky assets based on the strategic asset allocation of pension funds. The risky assets include allocations to equity and alternative asset classes (i.e., hedge funds, private equity, and real estate). Independent variables include *%Retired*, the percentage of retired members from total pension fund members; *%Retired* × *Public*, an interaction term capturing the percentage of retired members among public funds; *%Retired* × *U.S.*, an interaction term capturing the percentage of retired members among U.S. pension funds; *%Retired* × *Public* × *U.S.*, an interaction term capturing the percentage of retired members among U.S. public funds; $Yield_{t-1}$, the Treasury yield in the previous year; $Yield_{t-1}$ × *Public*, an interaction term capturing the effect of the previous year's Treasury yield on public funds; $Yield_{t-1}$ × *U.S.*, an interaction term capturing the effect of the previous year's Treasury yield on U.S. funds; and $Yield_{t-1}$ × *Public* × *U.S.*, an interaction term capturing the effect of the previous year's Treasury yield on U.S. public funds; *Fund size*, the logarithm of total pension fund assets; *Inflation protection*, a dummy variable taking a value of one if a fund provides a contractual inflation protection; *Public*, a dummy variable taking a value of one if a pension fund is public; *Public* × *U.S.*, a dummy variable for U.S. public funds; and *U.S.*, a regional dummy variable. Where indicated, we include year dummies and fund fixed effects. We independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Percentage allocated to risky assets						
%Retired	-0.164***	-0.170***	-0.101*	-0.071**	-0.130***	-0.112***	-0.080***
	[0.035]	[0.034]	[0.054]	[0.034]	[0.032]	[0.030]	[0.021]
%Retired × Public × U.S.		0.667***	0.696***	0.444***			
		[0.145]	[0.157]	[0.127]			
%Retired × Public			-0.000	0.007			
			[0.065]	[0.062]			
%Retired × U.S.			-0.094	-0.079**			
			[0.064]	[0.040]			
$Yield_{t-1}$	-0.009*	-0.014**	-0.011**	-0.007	-0.015**	-0.007	-0.002
	[0.006]	[0.006]	[0.005]	[0.010]	[0.006]	[0.005]	[0.009]
$Yield_{t-1}$ × Public × U.S.					-0.032***	-0.030***	-0.022***
					[0.006]	[0.008]	[0.008]
$Yield_{t-1}$ × Public						-0.012***	-0.024***
						[0.004]	[0.005]
$Yield_{t-1}$ × U.S.						0.016***	0.009*
						[0.006]	[0.005]
Fund size	0.014	0.013	0.012	0.004*	0.021	0.010	0.002
	[0.015]	[0.014]	[0.014]	[0.002]	[0.015]	[0.013]	[0.002]
Inflation protection				0.019***			0.021***
				[0.007]			[0.007]
Public × U.S.				-0.182***			0.082**
				[0.050]			[0.041]
Public				-0.008			0.120***
				[0.029]			[0.029]
U.S.				0.129***			0.052**
				[0.018]			[0.026]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	No	Yes	Yes	No
Double-clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,510	5,510	5,510	5,463	5,510	5,510	5,463
R^2	0.741	0.751	0.752	0.208	0.755	0.762	0.226

Table B.7: **Regressions: Percentage allocated to equity, alternatives and risky fixed income assets**

In this table, we estimate a panel model. The dependent variable is the percentage allocated to risky assets based on the strategic asset allocation of pension funds. In columns (1)–(4) the dependent variables measure the percentage allocated to equity, in columns (5)–(8) it covers the percentage allocated to alternative asset classes (i.e., hedge funds, private equity, and real estate), and in columns (9)–(12) it captures the percentage allocated to risky fixed income assets, such as high yield bonds, emerging markets debt and mortgages. Independent variables include *%Retired*, the percentage of retired members from total pension fund members; *%Retired* × *Public*, an interaction term capturing the percentage of retired members among public funds; *%Retired* × *U.S.*, an interaction term capturing the percentage of retired members among U.S. pension funds; *%Retired* × *Public* × *U.S.*, an interaction term capturing the percentage of retired members among U.S. public funds; *Fund size*, the logarithm of total pension fund assets; *Inflation protection*, a dummy variable taking a value of one if a fund provides a contractual inflation protection; *Public*, a dummy variable taking a value of one if a pension fund is public; *Public* × *U.S.*, a dummy variable for U.S. public funds; and *U.S.*, a regional dummy variable. Where indicated, we include year dummies and fund fixed effects. We independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Dependent variable: Equity assets				*Dependent variable: Alternative assets*				*Dependent variable: Risky fixed income*			
%Retired	-0.137***	0.028	-0.057**	-0.013	-0.030	-0.113***	-0.031**	-0.055***	0.002	-0.018	-0.013***	-0.014
	[0.035]	[0.046]	[0.023]	[0.036]	[0.023]	[0.034]	[0.013]	[0.017]	[0.007]	[0.020]	[0.005]	[0.009]
%Retired × Public × U.S.	0.262*	0.386**	0.257**	0.314***	0.382***	0.298*	0.145**	0.129*	0.101**	0.067	0.039**	0.042*
	[0.145]	[0.163]	[0.110]	[0.120]	[0.148]	[0.157]	[0.065]	[0.071]	[0.044]	[0.048]	[0.017]	[0.024]
%Retired × Public		-0.042		0.007		0.044		-0.000		0.025*		-0.009
		[0.070]		[0.059]		[0.041]		[0.022]		[0.014]		[0.014]
%Retired × U.S.		-0.228***		-0.119***		0.114***		0.037		0.027		0.009
		[0.066]		[0.042]		[0.038]		[0.024]		[0.023]		[0.011]
Fund size	0.018	0.014	-0.010***	-0.014***	-0.005	-0.003	0.019***	0.018***	-0.001	-0.000	0.003***	0.004***
	[0.016]	[0.015]	[0.004]	[0.003]	[0.011]	[0.010]	[0.002]	[0.002]	[0.004]	[0.003]	[0.001]	[0.001]
Inflation protection			-0.014*	0.012			-0.002	0.007			-0.003	-0.005**
			[0.007]	[0.008]			[0.006]	[0.006]			[0.002]	[0.003]
Public × U.S.			-0.069	-0.134***			-0.044*	-0.048*			-0.017***	-0.010
			[0.044]	[0.048]			[0.023]	[0.028]			[0.007]	[0.010]
Public				-0.005				-0.002				-0.001
				[0.029]				[0.013]				[0.008]
U.S.				0.122***				0.010				-0.012**
				[0.019]				[0.013]				[0.005]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No
Double-clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,510	5,510	5,463	5,463	5,510	5,510	5,463	5,463	5,510	5,510	5,463	5,463
R^2	0.757	0.761	0.158	0.216	0.755	0.758	0.241	0.253	0.727	0.728	0.112	0.123

Table B.8: **Regressions: Percentage allocated to risky assets**

Robustness check of Table 3: control for past net benchmark-adjusted performance (NTR–BM$_{t-1}$) or past net performance (NTR$_{t-1}$).

In this table, we estimate a panel model. The dependent variable is the percentage allocated to risky assets based on the strategic asset allocation of pension funds. The risky assets include allocations to equity, alternative asset classes (i.e., hedge funds, private equity, and real estate), high yield bonds, emerging market debt and mortgages. Independent variables include *%Retired*, the percentage of retired members from total pension fund members; *%Retired* × *Public*, an interaction term capturing the percentage of retired members among public funds; *%Retired* × *U.S.*, an interaction term capturing the percentage of retired members among U.S. pension funds; *%Retired* × *Public* × *U.S.*, an interaction term capturing the percentage of retired members among U.S. public funds; $Yield_{t-1}$, the Treasury yield in the previous year; $Yield_{t-1}$ × *Public*, an interaction term capturing the effect of the previous year's Treasury yield on public funds; $Yield_{t-1}$ × *U.S.*, an interaction term capturing the effect of the previous year's Treasury yield on U.S. funds; and $Yield_{t-1}$ × *Public* × *U.S.*, an interaction term capturing the effect of the previous year's Treasury yield on U.S. public funds; and *Fund size*, the logarithm of total pension fund assets. Additionally, we also control for the net benchmark-adjusted performance in the previous year (NTR–BM$_{t-1}$) or for the net performance in the previous year (NTR$_{t-1}$). In columns (5) and (6), we focus only on the 2001–2012 sample period. Where indicated, we include year dummies and fund fixed effects. We independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Percentage allocated to risky assets					
%Retired	-0.111*	-0.118***	-0.110*	-0.118***	-0.093	-0.107***
	[0.063]	[0.035]	[0.062]	[0.035]	[0.100]	[0.039]
%Retired × Public × U.S.	0.755***		0.754***		0.712***	
	[0.165]		[0.166]		[0.136]	
%Retired × Public	-0.002		-0.003		0.041	
	[0.064]		[0.064]		[0.060]	
%Retired × U.S.	-0.096		-0.097		-0.064	
	[0.074]		[0.074]		[0.107]	
Yield$_{t-1}$	-0.000	0.002	-0.000	0.002	-0.008	-0.010
	[0.006]	[0.005]	[0.006]	[0.005]	[0.005]	[0.008]
Yield$_{t-1}$ × Public × U.S.		-0.031***		-0.031***		-0.044***
		[0.008]		[0.008]		[0.010]
Yield$_{t-1}$ × Public		-0.010*		-0.010*		-0.001
		[0.005]		[0.005]		[0.006]
Yield$_{t-1}$ × U.S.		0.012**		0.012**		0.026***
		[0.006]		[0.006]		[0.010]
Fund size	0.013	0.013	0.013	0.013	-0.004	-0.017
	[0.015]	[0.015]	[0.015]	[0.014]	[0.018]	[0.019]
NTR–BM$_{t-1}$	0.000	0.000			0.000	0.000
	[0.000]	[0.000]			[0.001]	[0.000]
NTR$_{t-1}$			0.000	0.000		
			[0.001]	[0.000]		
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes	Yes	Yes
Double-clustering	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,382	4,382	4,382	4,382	2,813	2,813
R^2	0.752	0.758	0.752	0.758	0.808	0.812

Table B.9: **Regressions: Percentage allocated to risky assets**

Robustness check of Table 3: Examining regional differences.

In this table, we estimate a panel model. The dependent variable is the percentage allocated to risky assets based on the strategic asset allocation of pension funds. The risky assets include allocations to equity, alternative asset classes (i.e., hedge funds, private equity, and real estate), high yield bonds, emerging markets debt and mortgages. Independent variables include *%Retired*, the percentage of retired members from total pension fund members; $Yield_{t-1}$, the Treasury yield in the previous year; *Fund size*, the logarithm of total pension fund assets; *Inflation protection*, a dummy variable taking a value of one if a fund provides a contractual inflation protection; *Public*, a dummy variable taking a value of one if a pension fund is public; *U.S.*, *Canada* and *Europe*, regional dummy variables; and *Public* × *U.S.*, *Public* × *Canada*, and *Public* × *Europe*, dummy variables for U.S., Canadian and European public funds. We include year dummies and independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Percentage allocated to risky assets					
%Retired	-0.094***	-0.097***	-0.101***	-0.105***	-0.103***	-0.107***
	[0.024]	[0.024]	[0.022]	[0.022]	[0.022]	[0.022]
$Yield_{t-1}$	-0.001	-0.002	-0.001	-0.003	-0.001	-0.002
	[0.007]	[0.006]	[0.007]	[0.006]	[0.008]	[0.006]
Fund size	0.004*	0.006**	0.005**	0.008***	0.005**	0.008***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Inflation protection	0.007	0.002	0.014**	0.011	0.015**	0.012*
	[0.008]	[0.008]	[0.007]	[0.007]	[0.007]	[0.007]
Public			-0.021	-0.024*	-0.008	-0.030*
			[0.015]	[0.014]	[0.015]	[0.017]
U.S.	0.080***		0.084***		0.090***	
	[0.008]		[0.008]		[0.010]	
Canada		-0.069***		-0.072***		-0.077***
		[0.007]		[0.008]		[0.010]
Europe		-0.114***		-0.122***		-0.125***
		[0.018]		[0.018]		[0.019]
Public × U.S.					-0.021	
					[0.016]	
Public × Canada						0.015
						[0.018]
Public × Europe						0.008
						[0.045]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	No	No	No	No	No	No
Double-clustering	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,463	5,463	5,463	5,463	5,463	5,463
R^2	0.176	0.183	0.181	0.190	0.183	0.190

Appendix C: Liability discount rates

This appendix provides supplemental analysis on the discount rates used by pension funds to estimate the present value of their liabilities. Figure C.1 displays the trend in government bond yields and liability discount rates of public and private pension funds, separately for each region. It shows that U.S. public pension funds maintain steady discount rates around 7.5–8.0 percent during the entire period, while the other pension funds use substantially lower discount rates.

Our regulatory incentives hypothesis argues that the GASB guidelines give U.S. public funds an incentive to increase their allocation to risky assets with higher expected returns in order to justify a higher discount rate and report a lower value of liabilities. One test of this hypothesis posits that within U.S. pension funds, more mature funds have stronger incentives to maintain a higher liability discount rate. Reducing the discount rate creates larger immediate economic costs for mature U.S. public pension funds, because it increases more their required contribution payments.

Our identification is based on comparing U.S. public pension funds with public pension funds from other countries and with U.S. private pension funds. Table 4 presents the triple interaction term, which should be significant if U.S. public pension funds select their discount rates differently from all other pension funds. The interaction term *%Retired* × *Public* measures the relation between maturity and allocation to risky assets among all public plans. This term should be significant if fund type determines the relation between discount rate and maturity, regardless of regulatory differences. The interaction term *%Retired* × *U.S.* measures the relation between maturity and discount rates among all U.S. plans. This term should be significant if cross-country differences determine the liability discount rates, regardless of regulatory differences and fund type. The triple interaction terms *%Retired* × *Public* × *U.S.* measures the relation between maturity and liability discount rate only among U.S. public pension funds. This term is significant in Table 4, indicating that U.S. public plans choose their discount rates in a different way and the difference cannot be attributed to country or fund type effects. Thus, we attribute the differences in the discount rates to their distinct regulatory standards.

In the robustness results, we reduce the number of interaction terms and focus on two subsamples: (i) the subsample of all U.S. pension funds; (ii) the subsample of all public pension funds.

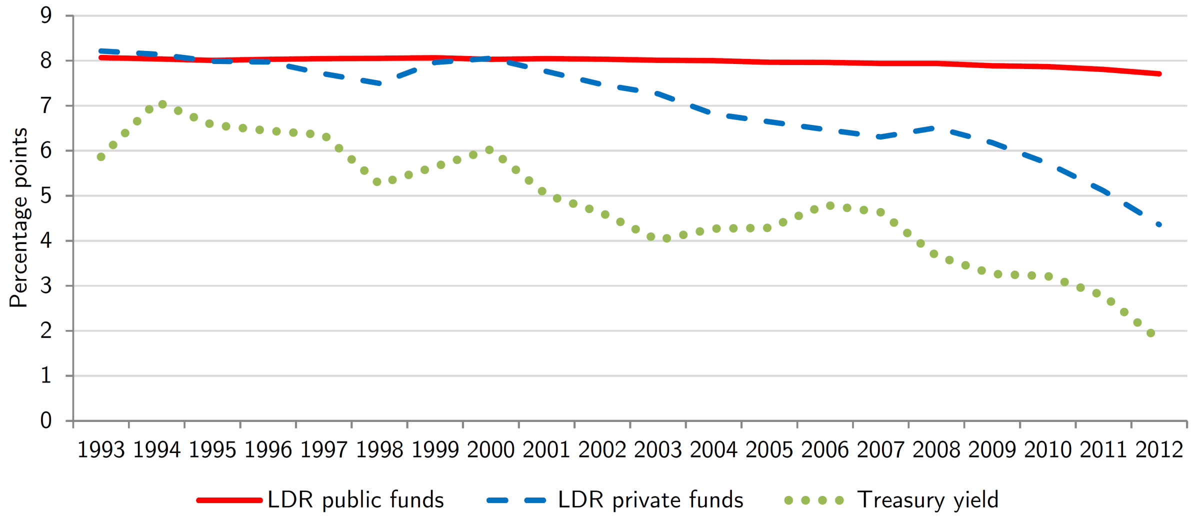
In Table C.1, we perform a cross-type analysis of the pension fund discount rates and focus only on the subsample of U.S. pension funds. This test shows that our results are not determined by differences across countries and the magnitude of our findings is even larger when we reduce the number of interaction terms. The results confirm that mature U.S. public funds use higher rates to discount their liabilities and their discount rates are not related to the dynamics in government bond yields.

We also perform a separate analysis only on the subsample of public pension funds, thus excluding all private funds. Table C.2 presents the results and indicates that U.S. public pension funds make different asset allocation decisions than public pension funds from Canada and Europe. The base results in this table refer to U.S. public plans and we include interaction terms for European and Canadian plans, because the samples from other countries are small. Namely, we have only 56 Canadian public funds (487 observations) and 9 European public funds (42 observations). Nevertheless, our results indicate that the positive relation between liability discount rate and fund maturity is present only among U.S. public pension funds. Similarly, the treasury yield is not related to the discount rate of U.S. public plan, while it is significantly positively related to the discount rate of Canadian plans.

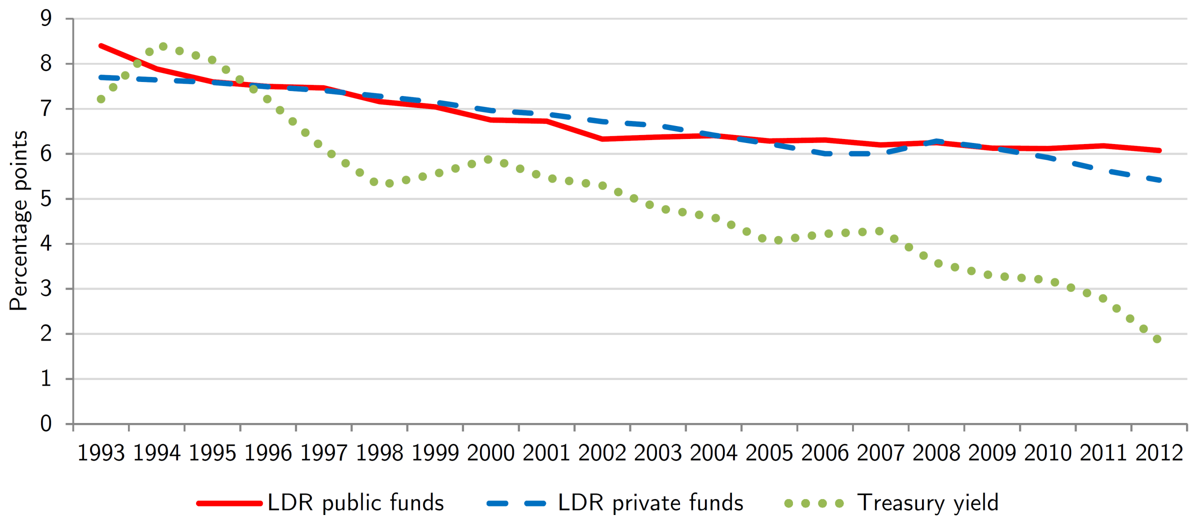
In the paper, we use the strategic asset allocation weights when calculating the riskiness of the investment policy. Table C.3 substitutes the percentage allocated to risky assets based on the strategic asset allocation policy with the percentage allocated to risky assets based on actual asset allocation policy and re-estimates the results from Table 4. The interaction terms *%Risky* × *Public* × *U.S.*, *%Risky* × *Public* and *%Risky* × *U.S.* are modified in a similar way. Our results do not change if we use the actual asset allocation instead of the strategic asset allocation.

Figure C.1: **Liability discount rates (LDR) and ten-year Treasury yields**

Panel A: U.S. pension funds



Panel B: Canadian pension funds



Panel C: European pension funds

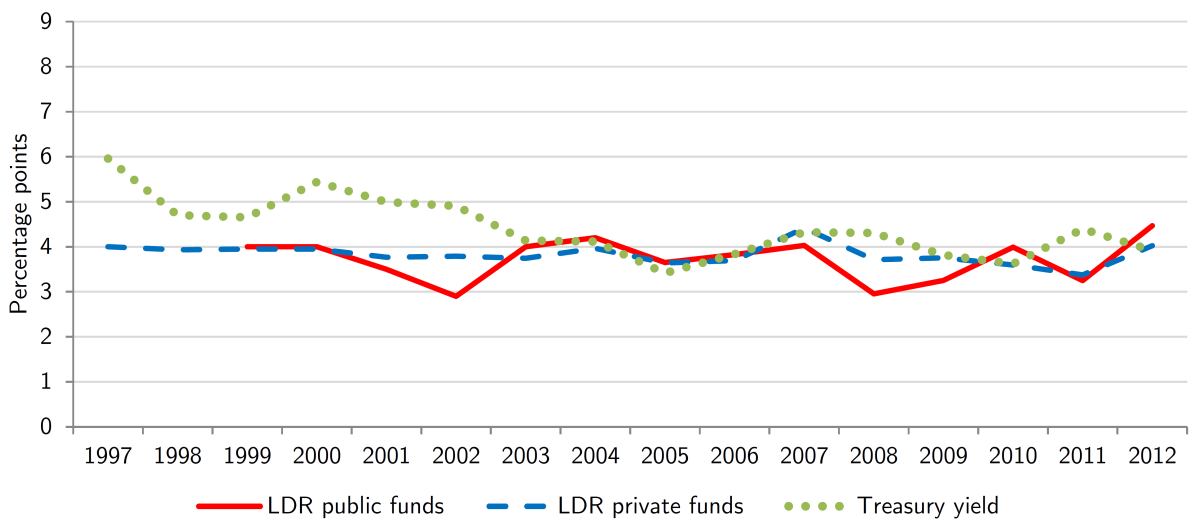


Table C.1: **Regressions: Liability discount rates of U.S. pension funds**

Robustness check of Table 4: cross-type analysis. In this table we analyze only the subsample of U.S. pension funds.

In this table, we estimate a panel model. The dependent variable is the liability discount rate used by U.S. pension funds. Independent variables include *%Risky*, the percentage strategically allocated to risky assets; *%Risky* × *Public*, an interaction term capturing the percentage allocated to risky assets of public funds; *%Retired*, the percentage of retired members from total pension fund members; *%Retired* × *Public*, an interaction term capturing the percentage of retired members among public funds; *Yield*, the ten-year Treasury yield; *Yield* × *Public*, an interaction term capturing the effect of the Treasury yield on public funds; *Fund size*, the logarithm of total pension fund assets; *Inflation protection*, a dummy variable taking a value of one if a fund provides contractual inflation protection; and *Public*, a dummy variable taking a value of one if a pension fund is public. Where indicated, we include year dummies and fund fixed effects. We independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Liability discount rate used by U.S. pension funds							
%Risky	2.349***	1.282**	1.452***	0.883*	0.456	0.753***	0.762*	0.394
	[0.510]	[0.575]	[0.351]	[0.461]	[0.346]	[0.270]	[0.424]	[0.256]
%Risky × Public		2.659***		1.520**	2.079***		-0.024	0.692*
		[0.980]		[0.748]	[0.535]		[0.651]	[0.399]
%Retired	-1.320***	-1.344***	-1.513***	-1.518***	-0.997***	-0.516**	-0.515**	-0.411***
	[0.339]	[0.335]	[0.392]	[0.387]	[0.185]	[0.225]	[0.220]	[0.127]
%Retired × Public			9.914***	9.471***	3.542***			
			[2.984]	[2.945]	[0.784]			
Yield	0.400***	0.421***	0.403***	0.415***	0.357***	0.539***	0.539***	0.464***
	[0.059]	[0.056]	[0.064]	[0.062]	[0.015]	[0.037]	[0.038]	[0.014]
Yield × Public						-0.608***	-0.609***	-0.596***
						[0.069]	[0.069]	[0.059]
Fund size	0.064	0.050	-0.134	-0.133	0.059***	-0.077	-0.077	0.027*
	[0.176]	[0.168]	[0.163]	[0.160]	[0.017]	[0.112]	[0.112]	[0.015]
Inflation protection					0.026			0.056
					[0.053]			[0.040]
Public					-1.755***			3.272***
					[0.388]			[0.448]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Double-clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,328	3,328	3,328	3,328	3,305	3,328	3,328	3,305
R^2	0.762	0.767	0.792	0.793	0.623	0.824	0.824	0.695

Table C.2: **Regressions: Liability discount rates of public pension funds**

Robustness check of Table 4: cross-country analysis. In this table we analyze only the subsample of public pension funds.

In this table, we estimate a panel model. The dependent variable is the liability discount rate used by public pension funds. Independent variables include *%Risky*, the percentage strategically allocated to risky assets; *%Risky* × *Canada*, an interaction term capturing the percentage allocated to risky assets by Canadian public funds; *%Risky* × *Europe*, an interaction term capturing the percentage allocated to risky assets by European public funds; *%Retired*, the percentage of retired members from total pension fund members; *%Retired* × *Canada*, an interaction term capturing the percentage of retired members among Canadian public funds; *%Retired* × *Europe*, an interaction term capturing the percentage of retired members among European public funds; *Yield*, the Treasury yield; *Yield* × *Canada*, an interaction term capturing the effect of the Treasury yield on Canadian public funds; *Yield* × *Europe*, an interaction term capturing the effect of the Treasury yield on European public funds; *Fund size*, the logarithm of total pension fund assets; *Inflation protection*, a dummy variable taking a value of one if a fund provides a contractual inflation protection; *Canada* and *Europe*, regional dummy variables. Where indicated, we include year dummies and pension fund fixed effects. We independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Liability discount rate used by public pension funds							
%Risky	0.431*	1.175***	0.359	0.980***	1.275***	0.282	0.594***	1.088***
	[0.255]	[0.352]	[0.224]	[0.295]	[0.299]	[0.219]	[0.204]	[0.250]
%Risky × Canada		-3.413***		-2.812***	-1.565		-1.311	-0.368
		[0.816]		[0.820]	[1.159]		[0.859]	[1.125]
%Risky × Europe		-1.782		-0.933	1.488		-1.221	1.903**
		[1.898]		[1.945]	[1.059]		[1.453]	[0.919]
%Retired	0.026	0.026	1.904**	1.429*	0.794**	-0.292	-0.260	-0.136
	[0.519]	[0.534]	[0.922]	[0.828]	[0.317]	[0.475]	[0.499]	[0.290]
%Retired × Canada			-4.279**	-3.184*	-1.333***			
			[1.922]	[1.827]	[0.478]			
%Retired × Europe			-6.182*	-4.820**	-2.077***			
			[3.214]	[2.380]	[0.634]			
Yield	0.374**	0.240	0.303*	0.210	0.258	-0.032	-0.038	-0.075
	[0.181]	[0.151]	[0.164]	[0.144]	[0.165]	[0.135]	[0.125]	[0.132]
Yield × Canada						0.312***	0.279***	0.279***
						[0.070]	[0.075]	[0.070]
Yield × Europe						-0.106	-0.131	-0.174
						[0.106]	[0.121]	[0.240]
Fund size	-0.331	-0.187	-0.299	-0.191	0.021	-0.027	-0.002	0.011
	[0.201]	[0.177]	[0.188]	[0.176]	[0.020]	[0.145]	[0.143]	[0.020]
Inflation protection					0.042			0.040
					[0.051]			[0.050]
Canada					0.178			-2.354***
					[0.822]			[0.861]
Europe					-4.282***			-4.509***
					[0.451]			[1.085]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Double-clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,859	1,859	1,859	1,859	1,858	1,859	1,859	1,858
R^2	0.869	0.878	0.876	0.881	0.715	0.891	0.892	0.731

Table C.3: **Regressions: Liability discount rates**

Robustness check of Table 4: Percentage allocated to risky assets variable, *%Risky*, as well as the interaction terms are based on the actual asset allocation, not the strategic assets allocation.

In this table, we estimate a panel model. The dependent variable is the liability discount rate used by the pension funds. Independent variables include *%Risky*, the percentage allocated to risky assets based on actual asset allocation policy; *%Risky* × *Public*, an interaction term capturing the percentage allocated to risky assets of public funds; *%Risky* × *U.S.*, an interaction term capturing the percentage allocated to risky assets of U.S. pension funds; *%Risky* × *Public* × *U.S.*, an interaction term capturing the allocation to risky assets of U.S. public funds; *%Retired*, the percentage of retired members from total pension fund members; *%Retired* × *Public*, an interaction term capturing the percentage of retired members among public funds; *%Retired* × *U.S.*, an interaction term capturing the percentage of retired members among U.S. pension funds; *%Retired* × *Public* × *U.S.*, an interaction term capturing the percentage of retired members among U.S. public funds; *Yield*, the ten-year Treasury yield; *Yield* × *Public*, an interaction term capturing the effect of the Treasury yield on public funds; *Yield* × *U.S.*, an interaction term capturing the effect of the Treasury yield on U.S. funds; and *Yield* × *Public* × *U.S.*, an interaction terms capturing the effect of the Treasury yield on U.S. public funds. *Fund size*, the logarithm of total pension fund assets; *Inflation protection*, a dummy variable taking a value of one if a fund provides contractual inflation protection; *Public*, a dummy variable taking a value of one if a pension fund is public; *Public* × *U.S.*, a dummy variable capturing U.S. public funds; and *U.S.*, a regional dummy variable. Where indicated, we include year dummies and fund fixed effects. We independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Liability discount rate used by pension funds							
%Risky	2.011***	1.034**	1.384***	0.239	1.236	0.980***	0.143	1.089
	[0.432]	[0.510]	[0.329]	[0.499]	[0.816]	[0.301]	[0.421]	[0.770]
%Risky × Public × U.S.		3.122***		1.527	2.079		0.317	0.612
		[0.694]		[1.052]	[1.460]		[0.850]	[1.334]
%Risky × Public				-0.048	0.370		0.055	0.263
				[0.819]	[1.257]		[0.507]	[1.288]
%Risky × U.S.				0.967	-0.580		0.678	-0.527
				[0.678]	[0.938]		[0.678]	[0.839]
%Retired	-1.156***	-1.151***	-1.308***	-0.159	0.253	-0.749***	-0.573***	-0.090
	[0.288]	[0.289]	[0.315]	[0.358]	[0.378]	[0.236]	[0.182]	[0.172]
%Retired × Public × U.S.			8.613***	7.798***	3.022***			
			[2.419]	[2.581]	[0.861]			
%Retired × Public				0.342	-0.390			
				[0.765]	[0.497]			
%Retired × U.S.				-1.547***	-1.005***			
				[0.452]	[0.385]			
Yield	0.076	0.007	0.017	0.017	0.097	0.011	0.068	0.138
	[0.079]	[0.069]	[0.077]	[0.074]	[0.245]	[0.078]	[0.081]	[0.234]
Yield × Public × U.S.						-0.460***	-0.601***	-0.497***
						[0.035]	[0.061]	[0.064]
Yield × Public							0.011	-0.096
							[0.048]	[0.065]
Yield × U.S.							0.286***	0.132
							[0.078]	[0.099]
Fund size	0.091	0.112	0.090	0.069	-0.093***	0.201*	0.032	-0.108***
	[0.119]	[0.110]	[0.129]	[0.118]	[0.035]	[0.109]	[0.095]	[0.033]
Inflation protection					0.161**			0.187**
					[0.079]			[0.075]
Public × U.S.					-1.817*			2.616***
					[1.021]			[0.966]
Public					0.257			0.645
					[0.863]			[0.952]
U.S.					1.618**			0.584
					[0.655]			[0.795]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Double-clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,328	5,328	5,328	5,328	5,289	5,328	5,328	5,289
R^2	0.819	0.823	0.831	0.834	0.554	0.842	0.850	0.591

Appendix D: Pension fund performance

We calculate the overall pension fund performance as the weighted average of the net benchmark-adjusted returns for each asset class held by the pension fund. In particular, we first calculate returns separately for each asset class by subtracting the investment costs and the benchmark return in that asset class from the gross returns, and then aggregate up across all asset classes held by the fund (weighting by their asset value).

The advantage of using net benchmark-adjusted returns instead of analyzing directly the net returns is that the benchmarks adjust for the first-order effect of the average performance of investments within each asset class, and in that sense thus control for the fund's actual asset allocation. For example, if a pension fund invests internationally, then the benchmark returns are a weighted average of indexes in multiple countries, weighted by the allocations across these countries.

If pension funds engaged just in passive investing, their net benchmark-adjusted returns would not be significantly different from zero. However, pension funds actively manage the majority of their holdings and this can potentially result in over or underperformance. CEM data provides information on the pension fund allocation to passively managed mandates. CEM Benchmarking Inc. defines passive assets (also called indexed) as investment mandates intended to replicate broad capital market benchmarks (e.g., the S&P500 for U.S. Stocks) or dedicated to matching a specific set of liabilities. Enhanced passive mandates that seek to add value over an index while maintaining a low tracking error are considered as active mandates.

Figure D.1 presents the average percentage allocated to passive mandates by all pension funds in the data. U.S. public pension funds have the same average as all other pension funds. The figure shows that pension funds manage around 80 percent of their assets actively and only 20 percent passively. Overall, pension funds engage primarily in active asset management and their performance can differ from the benchmark returns.

Even though pension funds on average manage the majority of their assets actively, it could be that those pension funds with a higher percentage allocated to risky assets allocate also more to passive mandates. If a pension fund has a limited active management capacity and expertise, but it wants to invest more in risky assets, the fund could increase the allocation to passive mandates within risky assets. In this case, we should observe a positive association between the percentage invested in passive mandates and the percentage invested in risky assets. Online Appendix Table D.1 examines this relation. We document no significant association between the percentage invested in passive mandates and the percentage invested in risky assets. The interaction term capturing the allocation to risky assets of U.S. public funds is also close to zero and insignificant. As a result, we conclude that we can take the allocation of active versus passive mandates as given, and consider how risk-taking incentives relate to pension fund net benchmark-adjusted performance.

D.I Analyzing the self-reported returns

The CEM database is anonymous and identifying pension funds is difficult, and researchers can only use this proprietary database on the condition that they respect this anonymity in their reporting of any results. The main motive for funds to enter the database is to benchmark their investment and administrative costs against peers. Funds sometimes decide to stop submitting the questionnaires to CEM for various reasons, such as termination of the service due to costs savings, mergers, acquisitions and bankruptcies of the underlying corporations, etc. Even though the database is anonymous, it is potentially vulnerable to self-reporting bias, because reporting to CEM is voluntary.

A potential bias in the reported pension fund returns can stem from two sources. First, pension funds may strategically report benchmarks that are "easy to beat." For instance, if U.S. private pension funds report lower benchmark returns than it will appear that they have higher net benchmark-adjusted returns than U.S. public funds. Second, pension funds may decide to stop reporting after or during a period of poor performance.

Regarding the first point, we examine closer the benchmarks reported by pension funds. In equity and fixed income, pension funds select well-established market indexes (like Russell 3000, S&P500, TSE300, MSCI World, Barclays U.S. Aggregate etc.) as their benchmarks.[4] Table D.2 presents the

[4]Benchmark returns can also be a weighted combination of multiple indexes. The realized returns and benchmark returns are generally provided in the local currency, but if an investor hedges the currency risk, than the hedged returns and benchmarks are provided. This is not surprising as many funds have currency overlay programs, but it shows that the self-reported benchmarks reflect the pension funds' asset management decisions. For instance, if we had to assume a benchmark for investments of Canadian pension funds in U.S. equity, then we will assume the same benchmark return for

most frequent self-reported benchmarks in equity, fixed income and alternative asset classes. We double check the reported return values for these benchmarks and find that they correspond to the values that we could calculate using other major financial datasets.

Furthermore, in Table D.3 Panel A, we examine closer the benchmarks reported by pension funds. We compare the benchmark returns in this table (NOT the pension fund realized returns) and we expect to find insignificant differences. If pension funds report similar benchmark returns, than we can argue that the differences in performance arise from poor asset management skills. However, we do not observe a difference in the benchmark returns reported by U.S. public pension funds and other pension funds in our sample. Table D.3 Panel A indicates that U.S. public pension funds report insignificantly lower benchmark returns than U.S. private pension plans. Thus, the lower performance of U.S. public plans cannot be justified with a strategic selection of benchmarks by other pension funds that can be easily outperformed.[5]

Regarding the second issue that pension funds may decide to stop reporting during or after a period of poor performance, earlier literature has conducted two self-reporting tests. Andonov, Bauer, and Cremers (2012) address the self-reporting problem by constructing a Cox proportional hazard model and test whether the decision of a particular pension fund to exit the database is related to its returns, costs or size. They find no evidence that the CEM database suffers from self-reporting bias related to performance. Their results also indicate that fund size has a negative effect on the fund's exit rate, with smaller funds much more likely to exit the CEM database. This result does not imply that the proportion of large and small pension funds changes over time. It merely shows that most large pension funds report during the entire sample period, whereas small pension funds enter and exit the database more frequently.

The second self-reporting test is conducted by Bauer, Cremers, and Frehen (2010). They address the self-reporting bias by matching the CEM data with the Compustat data and testing whether the decision to either start or stop reporting is related to the overall pension fund performance. Their

all of them (without taking into account differences in currency hedging policy or sector allocations across funds).

[5]In fixed income, private pension funds have significantly higher returns on their self-reported benchmarks than public pension funds, while in real estate it is the other way round. However, these differences are mainly to differences in allocation to asset class subcategories with fixed income and real estate securities (i.e., differences in allocations to direct real estate and REITs.)

results indicate that there is no evidence of a self-reporting bias related to performance in the exiting and entering years. In the paper, we document that U.S. public pension funds have lower returns than other groups of pension funds. Our finding will be biased if, for example, U.S. corporate pension plans are more likely to strategically enter and exit the CEM database based on their performance. The self-reporting results of Bauer, Cremers, and Frehen (2010) focus only on U.S. private pension plans and indicate that their performance is not related to their presence in the CEM dataset.

D.II Pension fund investment costs

When constructing the pension fund net benchmark-adjusted returns, we deduct not only the benchmark returns from the gross returns, but also the investment costs. Pension funds can manage their investments internally (in-house) or delegate the asset management to external (third-party) managers. The investment costs include the costs of all internal and external money managers hired by the pension fund to invest in all asset classes.

Internal investment costs include compensation and benefits of employees managing internal portfolios, as well as expenses for support staff, consulting, research, legal, trading services and allocated overhead costs. The overhead costs include expenses for rent, utilities, IT, investment accounting, financial control, HR, etc.

External investment costs capture the management fees paid to investment consultants and external asset managers. The performance fees, carried interest and rebates are directly subtracted from the returns and are not incorporated in the cost figures. External investments costs also include costs (compensation, benefits, travel and education costs) for internal staff whose sole responsibility is to select and monitor external managers. Thus, the net benchmark-adjusted returns remove all investment fees from the returns.

In alternative assets, pension funds also frequently hire fund-of-funds. For fund-of-funds, cost figures capture the base management fee paid to both the fund-of-funds manager and the underlying managers, but they do not include performance fees and carried interest on either level. Importantly, performance fees, carried interest and rebates are directly subtracted from the returns and are not incorporated in the cost figures. Thus, the net benchmark-adjusted returns remove all investment fees from the returns.

In Table D.3 Panel B, we present the summary statistics of pension fund investment costs. U.S. public funds have lower costs than other pension funds because they are larger. For instance, Table 1 in the paper shows that the median size of U.S. public pension funds in 2012 is more than $32 billion, whereas the median size of U.S. private pension funds in the same year is $8 billion.

D.III Pension fund performance in alternative assets

Equity and fixed income returns are based on market returns, so there is no smoothing or stale pricing in the pension fund returns in these asset classes. Performance measures in alternative asset classes are subject to stale asset prices. We use annual data, and real estate and private equity projects are typically appraised at least once a year. The largest alternative asset class in pension fund portfolio is direct real estate. Geltner and Goetzmann (2000) argue that the NCREIF Property Index, which captures direct real estate investments, is more like an annual index, as it is only partially updated each quarter. Hence, the use of annual returns in this paper should help minimize the problems associated with "stale" appraisals of direct real estate returns. Using higher frequency data will be more problematic.

Table D.2 reports the most frequent self-reported benchmarks in every alternative asset class. These benchmarks are also typically market indexes (for example, the NCREIF Index and the FTSE/NAREIT Index for U.S. real estate investments or the HFRI Index for hedge fund investments). In alternative asset classes, we also do not observe a difference between the benchmarks selected by U.S. public plans and other plans. Most importantly, pension funds do not beat their benchmarks on average. If the self-reported benchmarks were strategic, we would expect to observe that pension funds manage to obtain higher returns. The outperformance should be particularly visible in alternative asset classes, where the asset valuation is potentially subject to discretionary stale pricing. On the contrary, Andonov (2014) documents that pension funds on average obtain negative net benchmark-adjusted returns in all alternative asset classes. The underperformance is largest in hedge funds, where investors obtain an annual net benchmark-adjusted return of -1.12 percentage points. In real assets, funds underperform the benchmarks by 0.57 percentage points annually, whereas the underperformance in private equity is roughly 0.12 percentage points.

D.IV Bankruptcy of pension plan sponsors

CEM collects pension fund data through yearly questionnaires. If pension plans stop reporting, their old responses still remain in the database. Thus, a fund that submitted a survey in the past, does not need to exist today. For instance, based on information from CEM we know that the pension plans of United Airlines and National Steel participated in the CEM database. According to Brown (2008), these two pension plans are among the top ten largest funds taken over by PBGC after a bankruptcy of the sponsor. However, pension funds of sponsors that went bankrupt will not be part of the CEM database after the bankruptcy and termination. Nevertheless, we do not think that this will bias our results.

First, analyzing pension funds of bankrupt sponsors is problematic because they are managed by the PBGC. These pension plans do not determine the asset allocation and liability discount rate independently. For instance, PBGC Board determines the investment policy, and in 2014, it established a 30 percent target asset allocation for equities and other non-fixed income assets, and a 70 percent asset allocation for fixed income.[6] Therefore, pension plans of bankrupt sponsors are incomparable with the other private pension plans, because they are taken over by PBGC.

Second, Rauh (2009) documents that firms with poorly funded pension plans and weak credit ratings allocate a greater share of pension fund assets to safer securities such as government debt and cash, whereas firms with well-funded pension plans and strong credit ratings invest more heavily in equity. The results of Rauh (2009) are robust to controlling for lagged investment returns, suggesting that the lower allocation to risky assets by sponsors facing higher bankruptcy risk cannot be explained by poor lagged performance. Thus, the exclusion of plans sponsored by firms entering bankruptcy could bias the asset allocation of private pension funds against our results, as the U.S. corporate pension

[6] See the PBGC annual report for fiscal year 2014: `http://www.pbgc.gov/documents/2014-annual-report.pdf`.

funds that are not terminated and remain in the database will actually have a higher allocation to risky assets than the terminated pension funds.

With respect to the U.S. public pension funds, there is no survivorship bias. For instance, Orange County pension plan has participated in the CEM data from 1993 until 2010 (The county declared bankruptcy in December 1994). Additionally, the City of Detroit filed for bankruptcy in July 2013. This case created a lot of discussions on riskiness of pension promises, but it is after the end of our sample period.

Figure D.1: **Percentage allocated to passive investment mandates**

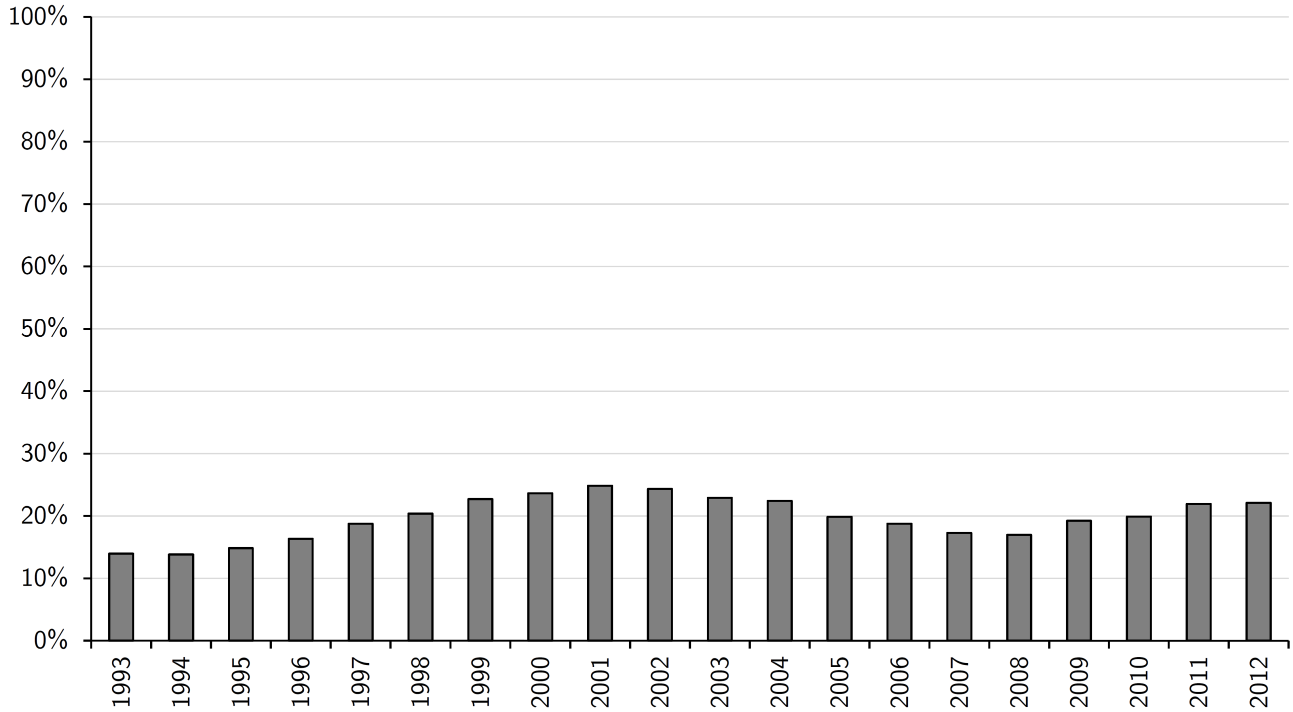


Table D.1: **Regressions: Percentage allocated to passive investment mandates**

In this table, we estimate a panel model. The dependent variable is the percentage allocated to passive investment mandates by the pension funds. Independent variables include *%Risky*, the percentage allocated to risky assets based on strategic asset allocation policy; *%Risky* × *Public*, an interaction term capturing the percentage allocated to risky assets of public funds; *%Risky* × *U.S.*, an interaction term capturing the percentage allocated to risky assets of U.S. pension funds; *%Risky* × *Public* × *U.S.*, an interaction term capturing the allocation to risky assets of U.S. public funds; *%Retired*, the percentage of retired members from total pension fund members; *Yield*, the ten-year Treasury yield. *Fund size*, the logarithm of total pension fund assets; *Inflation protection*, a dummy variable taking a value of one if a fund provides contractual inflation protection; *Public*, a dummy variable taking a value of one if a pension fund is public; *Public* × *U.S.*, a dummy variable capturing U.S. public funds; and *U.S.*, a regional dummy variable. Where indicated, we include year dummies and fund fixed effects. We independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1)	(2)	(3)	(4)
Dependent variable: Percentage allocated to passive mandates				
%Risky	0.015	-0.002	-0.144	-0.109
	[0.063]	[0.065]	[0.109]	[0.116]
%Risky × Public × U.S.		0.058	-0.112	0.038
		[0.145]	[0.169]	[0.310]
%Risky × Public			0.095	-0.036
			[0.065]	[0.193]
%Risky × U.S.			0.215	-0.088
			[0.138]	[0.153]
%Retired	0.000	-0.000	0.005	0.006
	[0.046]	[0.046]	[0.046]	[0.037]
Yield	-0.021	-0.022	-0.024	-0.029**
	[0.018]	[0.018]	[0.019]	[0.013]
Fund size	0.000	0.001	-0.001	0.016***
	[0.022]	[0.022]	[0.022]	[0.006]
Inflation protection				0.017
				[0.016]
Public × U.S.				0.019
				[0.211]
Public				0.003
				[0.123]
U.S.				0.060
				[0.105]
Year FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	No
Double-clustering	Yes	Yes	Yes	Yes
Observations	5,510	5,510	5,510	5,463
R^2	0.776	0.776	0.777	0.060

Table D.2: **Examples of self-reported benchmarks in the CEM data**

This table presents the most frequent return benchmarks in the largest asset classes. For equity and fixed income, we present the benchmark separately for investments in U.S. and other international markets. For real estate, we present the benchmarks separately for direct real estate and real estate investment trusts (REITs). In private equity, pension funds report benchmarks separately for venture capital, leveraged buyout and diversified private equity, which includes VC, LBO, turnarounds, start-ups, mezzanine, and distressed financing. We combine tactical asset allocation (TAA) mandates with investments in hedge funds, because they are benchmarked in a similar fashion.

	Benchmark description
Equity	
- U.S. equity broad	S&P 500; Russell 3000; Wilshire 5000; S&P 1500; Dow Jones U.S. Total Custom (XX% S&P500 + XX% Russell 2000)
- U.S. large caps	S&P 500; Russell 1000; MSCI USA; Russell 1000 Value Custom (XX% Russell 1000 Value + XX% S&P500)
- U.S. small and mid caps	Russell 2000; Russell 2500; Wilshire 4500; Wilshire 5000; Russell 2000 Value Russell 2000 Growth; S&P 400 MidCap
- EAFE/Global equity	MSCI EAFE; MSCI World; MSCI ACWIxUS; MS World xCan; MSCI EAFE xJapan MSCI EAFE GDP Weighted; Custom (XX% MSCI ACWxUS + XX% MSCI Emerging) MSCI Europe; FTSE All World; Custom (weighted average of multiple countries) FTSE 100; MSCI Emerging Markets
Fixed income	
- U.S. fixed income	Barclays U.S. Aggregate; Barclays U.S. Government/Credit Bond Index Citigroup (Salomon) Broad Investment Grade; Custom (average of multiple indexes)
- EAFE/Global fixed income	Citigroup World Govt Bond Index; DEX Universe Bond Index; JPM Non-U.S. Govt Citigroup Non-U.S. World Government Bond Index; Barclays Global Aggregate Merrill Lynch Euro Government bond index; J.P. Morgan EMU Govt JP Morgan Emerging Bond; Custom (weighted average of multiple countries)
Real estate	
- Direct real estate	NCREIF (national, regional or property types); Wilshire RE Securities IPD Global; RCPI; ICREIM/IPD; GPR 250; EPRA Global; Carnegie Real estate Custom (XX% NCREIF + XX% REIT); CPI + X%; Government bonds + X%
- REITs	FTSE EPRA/NAREIT; Wilshire REIT; MSCI US REIT; S&P/TSX REIT GPR250 Europe; FTSE EPRA/NAREIT Developed RE
Private equity	
- Venture capital	Cambridge VC; Thomson Venture Economic Index Equity index (Wilshire5000, MSCI Europe Small Cap) 1 Quarter Lag + X%
- Leveraged buyout	Equity indexes (S%P500 / Wilshire5000 / S&P/ASX / MSCI Europe + X%) Absolute return X%; Cambridge PE; Equity index 1 Quarter Lag + X%
- Diversified	Equity indexes (Russel2000 / Wilshire5000 / S&P/TSX / MSCI World + X%) S&P500 / Wilshire 5000 moving 3 year average Cambridge PE; Thomson Venture Economic Index Absolute return X%; LIBOR + X%
Hedge funds & TAA	
- Hedge funds	HFRI/HFRX Indexes (all indexes and sub strategies); Credit Suisse Indexes CPI + X%; Libor + X%; T-Bill + X%; Bank of Canada Overnight Rate + X% Equity indexes (S&P500, TSE300, FTSE); Custom (S&P500 + X%) Absolute return X%; 50% Absolute return X% + 50% S&P500
- Tactical asset allocation	Custom (XX% equity index + XX% fixed income benchmark) MSCI World (hedged or unhedged) CPI + X%; Libor + X%; Euribor + X%; T-Bill + X% Hedge fund indices (HFRI, HFRX and Credit Suisse Indexes) Absolute return X%

Table D.3: **Summary statistics: Benchmark returns and investment costs**

Panel A provides descriptive statistics for the self-reported benchmark returns by the pension funds and we show the mean benchmark returns for all funds and separately for U.S. funds. Panel B presents summary statistics of pension fund investment costs in percentage points. Columns *Public* and *Private* report the summary statistics separately for public and private pension funds. We report the statistics for all assets as well as separately for equity, fixed income and alternative assets. In alternative assets, we report summary statistics for the three most important subcategories: real estate, private equity and hedge funds. The *T-test* column is a t-statistic of the difference in benchmark returns or investment costs between public and private pension funds. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	All pension funds			**U.S. pension funds**		
	Public	Private	T-test	Public	Private	T-test
Panel A: Benchmark returns						
All assets	8.379	8.842	-1.491	8.604	9.037	-1.031
Equity	9.079	9.376	-0.568	9.508	9.673	-0.242
Fixed income	7.043	7.811	-4.508***	6.872	7.721	-4.017***
Alternative assets	9.353	8.319	3.041***	9.474	8.938	1.225
Real estate	9.601	7.918	4.889***	9.510	8.448	2.429***
Private equity	11.008	10.454	0.837	11.512	10.808	0.924
Hedge funds	4.366	3.901	0.791	4.562	4.012	0.759
Panel B: Investment costs						
All assets	0.320	0.374	-9.159***	0.349	0.437	-11.573***
Equity	0.263	0.352	-18.449***	0.268	0.377	-18.768***
Fixed income	0.147	0.192	-11.940***	0.162	0.226	-12.389***
Alternative assets	1.447	1.411	0.364	1.588	1.612	-0.166
Real estate	0.853	0.851	0.052	0.973	1.008	-0.681
Private equity	3.863	3.252	2.151**	4.121	3.001	3.499***
Hedge funds	1.777	1.861	-1.681*	1.749	1.785	-0.715

Appendix E: Governance and funding status of U.S. public funds

This appendix contains supplemental descriptive statistics and analyses about our U.S. public pension funds sample. We collect data on U.S. public (state and local) pension funds board composition and self-reported funding status from the Comprehensive Annual Financial Reports (CAFRs).

Figure E.1 presents the trend in self-reported funding ratios of U.S. public pension funds during the 1993–2012 period. Most of the U.S. public plans are underfunded and the average self-reported funding ratio decreases to 73 percent in 2012.

Figure E.2 breaks down pension fund board members by representation and appointment procedure. It presents the average board composition of U.S. public pension funds. In Table E.1, we present descriptive statistics for our three main dependent variables (percentage allocated to risky assets, liability discount rates and performance) by board composition. We estimate three regressions without a constant for each variable and the coefficient can be interpreted as averages for each group of trustees.

When analyzing the U.S. public funds, we include the following economic and demographic variables at the U.S. state level: public employee unionization rates, GDP per capita, GDP growth, population growth, and state and local government expenditures per capita. We present the summary statistics for these variables in the Online Appendix E.2. The public employee unionization rates data originally comes from the Bureau of Labor Statistics (BLS), was constructed by Barry Hirsch and David Macpherson and is available at `http://unionstats.gsu.edu`. The Bureau of Economic Analysis (BEA) provides the GDP per capita and GDP growth data. Population growth is reported by the Census Bureau. The data on state and local government expenditures per capita comes from the Census Bureau, Annual Survey of Local Government Finance. The government expenditures data is not available in 2001 and 2003, reducing our sample.

In Section 7 of the paper, we consider how the level of underfunding per participant and board composition relate to how U.S. public funds allocate to risky assets, choose liability discount rates and perform relative to their asset class benchmarks. To estimate the level of underfunding per participant depends we make multiple assumptions. We assume that the pension funds use the "Entry Age Normal" (EAN) actuarial method of liability recognition, and we adopt from Novy-Marx and Rauh (2011) several assumptions about the demographic characteristics of active and retired pension fund members.

As a robustness check, we perform an alternative estimation of the level of underfunding that requires only two assumptions. First, instead of making assumptions about the age and working career of retired and active participants, we assume that every pension fund has a duration of ten years, which is implied by the recent (GASB 2012) disclosures and follows Rauh (2016). Second, instead of relying on the EAN actuarial method, we estimate the value of "Accumulated Benefits Only" (ABO) liabilities. The EAN method recognizes some benefits that have not yet been formally earned under employee benefit factors, while ABO reflects only pension benefits that employees would be entitled to receive under their current salaries and years worked. Based on Novy-Marx and Rauh (2011) the typical ratio of ABO liabilities to EAN liabilities is 0.85, which ratio we use to reduce the liabilities to get our estimated value for the ABO liabilities.[7]

Table E.3 shows that our results are robust to the alternative simple calculation of the level of underfunding per participant. Our results provide supportive evidence for the hypothesis that pension funds with a higher level of underfunding per member invest more in risky assets and choose higher discount rates.

[7] We are grateful to Joshua Rauh for suggesting this alternative measure of underfunding.

Figure E.1: **Self-reported funding ratio (SRFR) of U.S. public pension funds**

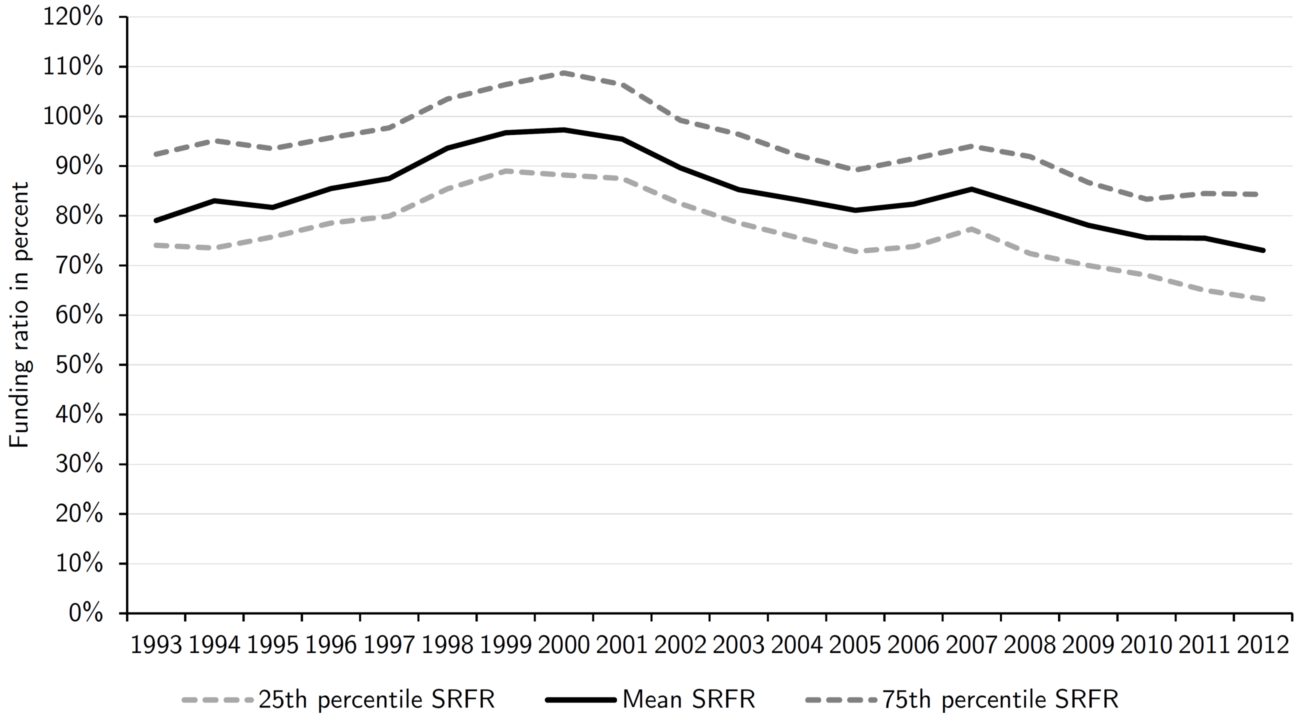


Figure E.2: **Average board composition of U.S. public pension funds**

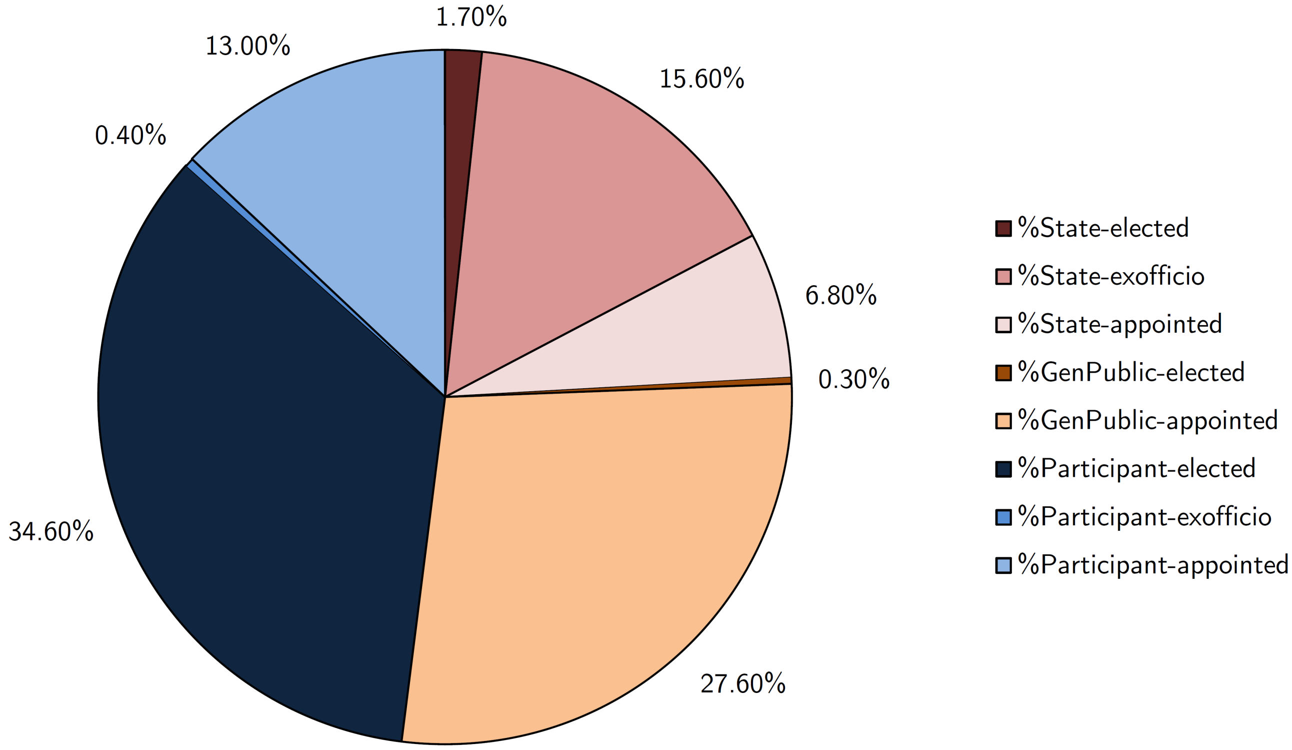


Table E.1: **Summary statistics: Board composition and main variables**

We split the board members in three categories. *%State* measures the percentage of board members representing the employer, i.e. state, county, city, or other public entity. State trustees can be elected to the board by plan members (*%State-elected*), be appointed by a government executive (*%State-appointed*) or serve as ex officio members by the virtue of holding another government position (*%State–ex officio*). *%GenPublic* measures the percentage of board members that represent the citizens (taxpayers) and do not work for the state or participate in the pension plan. General public board members can be either elected to the board by plan members (*%GenPublic-elected*), or appointed to the board (*%GenPublic-appointed*). *%Participant* measures the percentage of board trustees representing the currently employed and retired plan participants. Board members representing plan participants can be elected by plan members (*%Participant-elected*), be appointed to the board (*%Participant-appointed*), or serve as ex officio members, because they are union leaders (*%Participant–ex officio*). In each column, we estimate a regression without a constant and the dependent variables are percentage allocated to risky assets (*%Risky*), liability discount rate (*LDR*) used by the pension funds, and net benchmark-adjusted returns (*Returns*) of the pension funds.

	%Risky	LDR	Returns
%State-elected	0.704	7.022	1.440
	[0.037]	[0.120]	[1.022]
%State–ex officio	0.732	7.944	0.283
	[0.014]	[0.045]	[0.388]
%State-appointed	0.755	8.107	-0.036
	[0.023]	[0.075]	[0.642]
%GenPublic-elected	0.343	5.484	3.379
	[0.134]	[0.433]	[3.691]
%GenPublic-appointed	0.689	7.848	0.281
	[0.011]	[0.035]	[0.299]
%Participant-elected	0.702	8.129	-0.339
	[0.009]	[0.030]	[0.256]
%Participant–ex officio	0.802	8.420	-2.053
	[0.098]	[0.315]	[2.688]
%Participant-appointed	0.571	8.018	0.300
	[0.013]	[0.042]	[0.360]

Table E.2: **Summary statistics: Economic and demographic variables at the U.S. state level**

The summary statistics in this table are only for the subsample of U.S. public pension funds. *Unionization* presents the public employee unionization rates, and the data originally comes from the Bureau of Labor Statistics (BLS) and was constructed by Barry Hirsch and David Macpherson. *Population growth* is reported by the Census Bureau and the statistics are presented in percentage points. The Bureau of Economic Analysis (BEA) provides the *GDP per capita* (in dollars) and *GDP growth* data (in [percentage points). The data on state and local *government expenditures* per capita (in dollars) comes from the Census Bureau, Annual Survey of Local Government Finance. The government expenditures data is not available in 2001 and 2003, reducing our sample.

	Obs.	Mean	Median	StDev
Unionization	1,117	0.362	0.396	0.167
Population growth	1,117	0.997	0.813	0.931
GDP per capita	1,117	44,525	44,296	12,889
GDP growth	1,117	1.419	1.500	2.527
Government expenditures	975	9,215	8,929	1.908

Table E.3: **Regressions: The level of underfunding per member and governance**

Robustness check of Tables 8, 9, 10, and 11: The total underfunding is estimated by recalculating the reported "Entry Age Normal" (EAN) liability assuming a ten-year duration, and then multiplying by 0.85 for an "Accumulated Benefits Only" (ABO) correction. *Underfunding per participant* is estimated by dividing the total underfunding in $million (difference between the liabilities discounted with the ten-year Treasury rates and the actuarial assets) with the total number of active and retired plan members.

The dependent variables are the percentage of retired members, the percentage allocated to risky assets, the liability discount rate, and the net benchmark-adjusted performance of U.S. public pension funds. We include the following board composition variables in the models. *%State-political* captures the percentage of board members representing the employer (state, country, city, or other public entity), who are either appointed by a government executive or serve as an ex officio member by the virtue of holding another government position. *%PlanMem-elected* measures the percentage of board members representing the plan participants, who are either elected by the plan members or serve on the board as union leaders. *%GenPublic-appointed* measures the percentage of board members appointed from the general public. We also control for *Board size*, the total number of pension fund board members, and *InvBoard*, an indicator equal to one if a pension fund has a separate investment board. *Fund size* measures the logarithm of total pension fund assets. *%External* captures the percentage of assets delegated to external managers and *%Active* is the percentage of assets managed actively. We control for the following economic variables on a state-level: public employee unionization rates, GDP per capita, GDP growth, and population growth. Every regression includes year fixed effects and state fixed effects. We also independently double-cluster the robust standard errors by pension fund and by year. We report standard errors in brackets. *, **, and *** indicate significance levels of 0.10, 0.05, and 0.01, respectively.

	(1) %Retired	(2) %Risky	(3) LDR	(4) Returns
%Retired		-0.045	0.672*	0.582
		[0.121]	[0.371]	[1.534]
Underfunding per participant	0.259***	0.140*	0.972**	-1.239
	[0.066]	[0.083]	[0.401]	[2.225]
%State-political	0.090**	0.107***	0.543**	-1.430**
	[0.037]	[0.040]	[0.219]	[0.557]
%PlanMem-elected	0.150***	0.069**	0.051	-1.438***
	[0.034]	[0.034]	[0.145]	[0.459]
%GenPublic-appointed	0.032	0.134***	0.628***	-0.749
	[0.026]	[0.042]	[0.215]	[0.570]
Fund size	-0.013***	0.005	0.008	-0.110
	[0.003]	[0.003]	[0.015]	[0.135]
%External				-0.387
				[0.279]
%Active				0.003
				[0.692]
Board size	0.000	0.001	0.014	0.100**
	[0.002]	[0.002]	[0.011]	[0.049]
InvBoard	-0.013	-0.004	-0.240**	0.227
	[0.026]	[0.015]	[0.118]	[0.342]
Unionization	-0.173***	0.040	-0.520*	-1.467
	[0.040]	[0.108]	[0.285]	[1.209]
Population growth	0.003	-0.002	-0.005	0.138***
	[0.002]	[0.003]	[0.011]	[0.042]
GDP per capita	-0.014	-0.035	-0.029	-0.135
	[0.014]	[0.031]	[0.069]	[0.425]
GDP growth	0.000	0.001*	0.005**	0.025
	[0.001]	[0.001]	[0.003]	[0.070]
Year FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Double-clustering	Yes	Yes	Yes	Yes
Observations	1,117	1,117	1,117	1,117
R^2	0.694	0.466	0.597	0.163

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