Pension Fund Asset Allocation and Liability Discount Rates: Camouflage and Reckless Risk Taking by U.S. Public Plans?

Aleksandar Andonov
Maastricht University

Rob Bauer
Maastricht University

Martijn Cremers
University of Notre Dame

Please do not quote or distribute this version without authors' permission

March 2013

Abstract

Using an international pension fund database, we compare the asset allocation, liability discount rates and performance across 6 groups: public and private funds in three regions (U.S., Canada and Europe). U.S. public funds face distinct regulations linking expected returns to liability discount rates and accordingly they behave differently from all other pension funds. In the past two decades, U.S. public funds uniquely increased allocations to riskier investments to maintain high discount rates (especially as more members retired), camouflaging the degree of underfunding. Consistent with economic theory, all other groups of pension funds reduced allocations to risky assets as they mature, and lowered discount rates as interest rates declined. The increased risk-taking of U.S. public funds is associated with annual underperformance of over 60 basis points.

JEL classification: G11, G18, G23, H55.
Keywords: pension funds, public, defined benefit, risk-taking, asset-liability management, asset allocation, liability discount rates, retired, mature, regulation.

Acknowledgements
Contact authors via email at a.andonov@maastrichtuniversity.nl, r.bauer@maastrichtuniversity.nl and mcremers@nd.edu. We thank CEM Benchmarking Inc. in Toronto for providing us with the CEM database. For helpful comments and suggestions, we thank Keith Ambachtsheer, Dirk Broeders, Jeffrey Brown, Frank de Jong, Theo Kocken, Ranji Nagaswami, Theo Nijman, Peter Schotman and seminar participants at the Ohio State University, Luxembourg School of Finance, Maastricht University, American Economic Association (AEA) Annual Meeting, Fourth Joint World Bank/BIS Public Investors Conference, Netspar Pension Fund Conference, Notre Dame and The Nasdaq OMX Educational Foundation Conference and German Finance Association (DGF). We acknowledge research funding provided by Inquire Europe and by Rotman International Centre for Pension Management at the Rotman School of Management, University of Toronto (ICPM). All errors are our own.

1. Introduction

Pension funds around the world are in a state of flux. In the past two decades, funds have been confronted with financial crises, a maturing participant base, decreasing treasury yields, tightening regulation and, as a result, increasing demands for transparency and accountability. Moreover, most defined benefit (DB) pension funds are underfunded and have fewer assets than the pension promises they made, despite the fact that the valuation of the size of these liabilities in many cases is severely underestimated (see Novy-Marx and Rauh (2011)).

The challenge for members of the Board of Trustees of DB pension funds – in conjunction with other stakeholders – is how to decide and periodically update critical aspects of their fund's policy, such as the contribution levels of plan members, strategic allocations across various asset classes and the kind of inflation protection offered, using projections of their liabilities (i.e., pension promises) and their expected future income from investments. When considering their fund's asset-liability management, boards need to decide on a few key input parameters such as the level of expected returns, interest and inflation rates, and on the discount rate used to value the liability stream, as well as on a number of actuarial indicators such as life expectancies.

The amount of latitude boards have in this process depends on the regulatory framework in which they operate. In general, these decisions could be left at the full discretion of the pension funds, or, at the other side of the spectrum, be heavily restricted by regulation or public policy. Previous literature (see e.g. Novy-Marx and Rauh (2009, 2011) and Brown and Wilcox (2009)) has shown that regulation pertaining to U.S. public pension DB plans is relatively opaque and leaves wide discretion to their boards. In this paper, we compare the regulatory framework of U.S. public pension plans with that of U.S. private funds as well as to both public and private international funds. We argue that the regulatory environment for U.S. public funds is distinct, setting them apart from Canadian and European public pension funds as well as from private pension funds in all three of the regions for which we have data (i.e., U.S., Canada and Europe).

U.S. public funds are distinct in that they can decide their strategic asset allocations and liability discount rates largely without regulatory interference, due to wide discretion allowed in the currently applicable Government Accounting Standards Board (GASB) guidelines. In particular, these guidelines link the liability discount rates of U.S. public funds to the (assumed or estimated) expected rate of returns of the assets, rather than to the riskiness of the liabilities as suggested by economic theory. As a result, over the last

two decades U.S. public funds have been able to maintain high liability discount rates, even as interest rates significantly declined, by increasing allocations to assets with higher (assumed) expected returns. The regulation pertaining to U.S. public funds thus provides strong incentives to shift to risky investments assets that allows these funds to camouflage the degree of underfunding. In contrast, U.S. private pension funds and (both public and private) Canadian and European pension funds are arguably subject to significantly stricter regulatory guidelines. Their regulations generally proscribe that liability discount rates should be chosen as a function of current interest rates (see e.g. the Canadian Institute of Actuaries (2011) and Crossley and Jametti (2011)) as advocated by economic theory literature (see Sundaresan and Zapatero (1997), Lucas and Zeldes (2009), Novy-Marx and Rauh (2009, 2011) and Brown and Wilcox (2009)).

The main contribution of this paper is to empirically document that the asset allocation and liability valuation of U.S. public DB pension funds have changed very differently in response to two critical developments in the last 20 years, both of which are exogenous to individual pension fund boards and have profound economic implications. The first development is the maturing of member populations, i.e. that the percentage of retired members (current or past workers who are beneficiaries) as a fraction of all members has significantly increased and thus the percentage of members paying into the defined benefit plan has decreased. On average, the percentage of retired members among private plans increased from 31% in 1993 to 52% in 2010, and from 28% in 1993 to 39% percent in 2010 among public pension funds. The second development is the steady decline in interest rates over this period. For example, the 10-year U.S. Treasury yield fell from about 7% in 1994 to about 3% in 2010.

The main results for these two developments are as follows. The first major issue is the increased proportion of retired members. Economic theory suggests that asset allocation and liability discount rate choices should be more conservative as the fund matures (see Lucas and Zeldes (2006, 2009), Sundaresan and Zapatero (1997), and Benzoni, Collin-Dufresne and Goldstein (2007)). We find that this is indeed how pension funds have generally responded. However, U.S. public funds are unique in *not* choosing more conservative asset allocations and *not* choosing lower discount rates as their plan member base matures. Instead, for U.S. public funds the proportion of retirees relative to non-retirees is *positively* related to the allocation to risky assets: with a 10 percentage point increase in the proportion of retired members being associated with an increase in the allocation to risky assets of more than one percentage point. Similarly and

again in contrast to the other funds in our sample, for U.S. public funds we find a positive association between their liability discount rates and the proportion of retired members.

The second major development is the significant decline in interest rates over our time period in each of the three regions we consider. The main theoretical prediction relates to the choice of the liability discount rate. Financial theory suggests that future streams of pension payments should be discounted at a rate that reflects their inherent riskiness and in particular their covariance with priced risks. Beneficiaries of pension promises, for both public and corporate entities, seem well protected by law, such that these pension payments are relatively certain or bear relatively little systemic risk (see e.g. Brown (2008) and Brown and Wilcox (2009)).[1] As a result, Brown and Wilcox (2009) and Novy-Marx and Rauh (2011) propose using liability discount rates based on yields on government and municipal bonds and swap rates.

In our empirical analysis, we find that pension funds generally lower liability discount rates as interest rates decline. However, U.S. public pension funds are again different, as we find no association between liability discount rates and interest rates, consistent with their incentives and their distinct regulation that explicitly links liability discount rates to the expected rate of return on the assets rather than to interest rates. As this result holds even while controlling for the proportion of risky assets, that means that U.S. public pension funds have made the economically surprising choice of not lowering their *nominal* expected return estimates on risky assets as interest rates decline.

Moreover, we find that an increasing majority of U.S. public pension funds manages the asset side of the balance sheet by smoothing the valuation of the assets across time, for which applicable valuation standards allow wide discretion (see e.g. Actuarial Standards Board (2007, 2009)). We document that U.S. public pension funds with higher allocations to risky assets are more likely to smooth asset valuations, possibly because smoothing masks the volatility of the performance of risky investments.

We also study the decision to provide contractual inflation protection. We document that public pension funds (especially in the U.S.) are more likely to promise inflation-indexed pensions to their participants. Brown and Wilcox (2009) argue that funds promising inflation protection should use risk-free real interest rates (e.g. yields on TIPS) to discount their pension promises. However, we find no association

[1] For public funds, pension promises in the U.S. are usually backed by constitutional non-impairment clauses as well as through statutory and common law (Brown and Wilcox (2009)). The Pension Benefit Guarantee Corporation backs pension promises of corporate defined benefit plans in the U.S. Even if a firm enters bankruptcy with insufficient pension assets to cover its liabilities to workers, plan participants will still receive their annual pensions up to a statutory maximum amount.

between liability discount rates and whether or not the DB fund offers inflation protection. This indicates that funds may be underestimating the costs of their inflation protection promises.

In conclusion, over the past 20 years U.S. public pension funds uniquely increased their allocation to riskier investment strategies that allowed them to maintain high discount rates and present lower liability valuations. They increased allocations to risk assets especially if their proportion of retired members increased. At the beginning of our sample in 1990, U.S. public pension funds had liability discount rates and allocations to risky assets that were similar to the other funds in our sample. By the end of our sample period in 2010, U.S. public funds as a group had the highest discount rates (190 basis points above U.S. corporate funds and even more above typical discount rates of Canadian and European funds) as well as the largest allocations to risky assets (on average 73.4% compared to an average of 65.7% for U.S. private funds, while Canadian and European funds have even lower allocations to risky assets).

This risk-taking behavior can be explained by the GASB rules linking liability discount rates to the riskiness of the assets creates the incentive to invest more in risky assets in order to keep liability discount rates high and present lower liability valuations and thus a better funding position. Our results point to a basic conflict of interest between current and future stakeholders of U.S. public pension funds. Current stakeholders (including boards, members and their representatives as well as politicians and taxpayers) have a direct incentive to underestimate the current value of existing liabilities and transfer this risk to future generations. In this era of general underfunding, when the average self-reported funding ratio of U.S. public funds in 2010 is 75 percent, such underestimation may allow current members to receive higher benefits without pension fund boards and politicians having to make tough choices now.[2]

Our results further suggest that part of the asset allocation decision may be driven by considerations other than asset-liability management and views on where the best investment opportunities are. In effect, the increased risk-taking would arguably be reckless to the extent that it is not driven by such economic considerations but rather by a desire to camouflage or make up for underfunding. We find some evidence

[2] A recent example can illustrate the economic magnitude. The actuary of CalPERS recommended lowering the liability discount rate from 7.75% to 7.25%, according to a news article (Bloomberg News, March 7, 2012, "CalPERS Should Cut Assumed Return to 7.25% From 7.75%, Actuary Recommends"). That article states: "Lowering the return would boost the state's employee pension costs, as a percent of payroll, as much as 4.2 percent in the year beginning July 1, according to a CalPERS staff report. Local governments could see an increase of as much as 4.5 percent the following year. The costs for some public-safety agencies could jump as much as 6.5 percent. ... The board rejected a similar proposal ... last year. Board members at the time expressed concern that lowering the rate to 7.5 percent would burden local governments when they were already facing financial strains." One week later (see "CalPERS Lowers Investment Target to 7.5%," Wall Street Journal, March 14, 2012), the CalPERS board decided to indeed lower the discount rate, but by only half as much as recommended by its actuary.

that the increased risk-taking of U.S. public pension fund has resulted in an underperformance of more than 60 basis points annually (on a net benchmark-adjusted basis and compared to all other pension funds), which is consistent with asset allocation decisions being made sub-optimally. Moreover, the underperformance of U.S. public pension funds is larger for funds that are more mature. A 10 percent increase in the maturity of U.S. public pension funds is associated with 25-48 basis points lower net benchmark-adjusted returns.

We discuss policy implications by comparing U.S. public funds to public funds in Europe (mainly funds from the U.K. and the Netherlands) and Canada, as well as to corporate funds in all three regions. The results for Canadian and European funds suggest that public and private funds behave similarly when they face a similar regulatory environment. As a result, our basic policy recommendation is to bring U.S. public fund regulation in line with the regulation applying to U.S. private funds and (either public or private) Canadian / European funds. We argue that the current regulatory framework pertaining to U.S. public pension funds provides the wrong incentives: plans that are underfunded can adopt riskier investment strategies that enable them to use higher discount rates and present lower liabilities in the official reporting of pension funding status. This increased risk-taking allows them to camouflage their actual underfunding levels and postpone greater scrutiny or difficult choices. In addition, it may lead to suboptimal investment decisions, giving rise to the worry that the increased risk-taking is reckless and may lead to substantial future costs to taxpayers or public entities.

We employ the unique international CEM database that contains detailed information on pension fund maturity, liability discount rates and inflation indexation policy (all previously unexplored) as well as on not just the actual allocations across many detailed asset classes, but also their long-term strategic asset allocation weights (which change only every few years on average and are thus unaffected by short-term market movements) as approved by the pension boards. CEM collects asset allocation data at a de-aggregated level (i.e., within broad asset classes like fixed income, many different investments are separately identified), which enables us to directly measure the riskiness of the asset allocation policy. Finally, the database covers three regions (U.S., Canada and Europe) and thereby allows us to compare public versus private pension funds across different international regulatory environments. To obtain more information on U.S. public pension funds we merge the CEM data with the Comprehensive Annual Financial Reports (CAFRs) submitted by U.S. public plans. The relatively long time series and broad cross-sectional coverage provide strong statistical power, such that our main results are derived in pooled panel regressions with

pension fund fixed effects as well as year fixed effects, using robust standard errors that are independently double-clustered in both the time and fund dimensions. The CEM database thus offers an exclusive viewpoint on the asset-liability management of pension funds around the globe. CEM data has been used previously by e.g. French (2008) to study the cost of active investing, and by Andonov, Bauer and Cremers (2011) to examine the asset allocation, market timing and security selection skills of pension funds.[3]

The remainder of the paper is organized as follows. In section 2, we briefly discuss the regulatory environment of pension funds for the three regions we investigate. Moreover, we discuss how pension fund regulation affects asset allocation decisions and the choice of the liability discount rate. Section 3 introduces the pension fund databases we use and provides summary statistics on our key variables of interest. In section 4, we investigate how the allocation to risky assets is related to characteristics in our pension fund database. Furthermore, we investigate which funds, and to what extent, use the possibility to smooth the valuation of the assets. In section 5, we explore how reported liability discount rates are related to pension fund characteristics and which funds are more likely to provide inflation protection to their members. Section 6 examines whether the increased risk-taking of certain pension funds results in better performance. Section 7 concludes with a discussion of policy implications, including the recent GASB (2011) proposals – pertaining only to U.S. public funds – that would severe the link between liability discount rates and expected rates of returns but only for funds that can be classified as underfunded.

2. Optimal asset allocation and regulation of pension funds

In this section, we explain the predictions about the risk-taking behavior and the choice of the liability discount rates of pension funds (and how these relate to fund maturity and interest rates) from two different perspectives. We first consider economic theory, and then possible short-term incentives in the context of underfunded defined benefit pension plans and regulation. Risk-taking behavior means the proportion of assets invested in risky assets, such as public equity, private equity, real estate and alternative assets. The liability discount rate refers to the rates that are used by the pension funds to discount their projections of future pension payments. In our empirical section, we test these predictions about how the

[3] Other papers studying pension fund performance using the CEM database are Bauer, Cremers and Frehen (2010), Dyck and Pomorski (2011) and Andonov, Eichholtz and Kok (2012). Our findings are in line with the predictions of Brown and Wilcox (2009) and Lucas and Zeldes (2009) that accounting rules for U.S. public pension funds create a perverse incentive to invest more in riskier assets in order to discount liabilities at a higher rate. We confirm this prediction by documenting that over time and as a group, U.S. public funds (have) become the biggest risk-takers among pension funds around the globe. Our findings on U.S. corporate funds are in line with Rauh (2009), who also documents a positive correlation between risk taking and the share of active employees in the corporate pension plans.

level of interest rates, plan maturity and contractual inflation protection relate to the allocation to risky assets and the liability discount rate.

2.1 The relation between risk taking, fund maturity and inflation protection

Theoretical models imply that the optimal asset allocation should be a function of fund maturity, salary growth and promised inflation protection. In principle, these variables should have similar effects across all funds, regardless of geographical region, regulatory requirements and plan type (public or corporate).

First, economic theory and empirical work argue that the correlation between returns on risky assets and the growth in average aggregate labor earnings are positively correlated in the long-run, although short-run correlation is typically low. Lucas and Zeldes (2006) show theoretically that when labor earnings growth and stock returns are positively correlated over longer horizons, obligations to older workers and retirees behave more like bonds and can be valued and hedged as such. However, because of future salary risk, obligations to younger workers are risky or behave more like stocks. As a result, Sundaresan and Zapatero (1997) and Lucas and Zeldes (2009) argue that the proportion of pension fund assets invested in risky assets should be positively related to the percentage of active participants, as pension benefits are tied to salaries, which are positively correlated with stock returns in the long-run.

Rauh (2009) finds a positive correlation between risk taking and the share of active employees in U.S. corporate pension plans, whereas Lucas and Zeldes (2009) find a positive, but statistically insignificant coefficient on the share of active participants among U.S. public funds. Compared to this prior research, we can examine not only the cross-sectional dimension, but also how allocations to risky assets have changed over a relatively long and dynamic time period. Moreover, we can incorporate international evidence on public as well as corporate pension plans. For instance, the sample in Lucas and Zeldes (2009) consists of 109 state and 87 local plans in a single year (2006), whereas Rauh (2009) focuses only on U.S. corporate funds. Our sample includes 804 public and corporate defined benefit pension funds in three regions over a 20-year period.

Further, Campbell and Viceira (2005) argue that optimal pension fund asset allocation also depends on the contractual indexation policy, i.e., whether the liabilities are fixed in real or nominal terms, and show

that holding bonds to maturity is akin to accumulating inflation risk. Boudoukh and Richardson (1993) and Schotman and Schweitzer (2000) document that stocks can serve as an inflation hedge in the long run.

Regarding the appropriate rates to discount the pension liabilities, financial theory suggests that the streams of future pension payments should be discounted at a rate that reflects the inherent risk of these cash flows, and in particular their covariance with priced risks. In the case of pension funds, the 'risk' associated with the liabilities relates primarily to whether the promised benefits will be paid in full in the future. For public funds, pension promises in U.S. are usually backed by constitutional non-impairment clauses as well as through statutory and common law (Brown and Wilcox (2009)). Pension promises of corporate defined benefit plans in the U.S. are backed by the Pension Benefit Guarantee Corporation. If a firm enters bankruptcy with insufficient pension assets to cover its liabilities to workers, the U.S. government provides plan recipients with their annual pensions up to a statutory maximum amount. In addition, underfunded corporate plans have to contribute a deficit reduction ("catch-up") contribution.[4] Hence, pension promises of both public and corporate funds are well protected, such that there is little uncertainty about whether the promised benefits will have to be paid. As a result, Brown and Wilcox (2009) and Novy-Marx and Rauh (2011) propose using treasury rates, municipal rates and swap rates to discount pension liabilities, because these rates reflect the low uncertainty pertaining to the promised pension payments.

The implication that follows is that liability discount rates should decrease in line with decreasing government bond yields. Further, as the yield curve is generally upward sloping, we would expect that more mature pension funds, i.e. plans whose liabilities have shorter durations, should typically use lower discount rates than younger funds. Furthermore, public pension funds should use lower discount rates than corporate funds, as benefits of public plans are virtually free of risk as they are usually backed by constitutional guarantees, while members of private plans still risk losing part of their pensions if the firm enters bankruptcy.

2.2 How pension fund regulation affects asset allocation decisions and liability discount rates

We examine the effect of differences in pension fund regulation by contrasting the regulatory framework for U.S. public funds with that pertaining to U.S. corporate funds and both public and corporate pension funds in Canada and Europe. Specifically, we argue that these regulatory differences give rise to

[4] Brown (2008) presents the examples of Bethlehem Steel, US Airways and other companies with underfunded defined benefit pension funds and discusses flaws in the pension insurance system.

different incentives about the choice of the proportion of assets invested in risky asset classes and the liability discount rate used. The main difference across funds consists of regulations of the liability discount rates. U.S., Canadian and European funds generally face few limits on the proportion of investments they can make in risky assets (see the OECD 2011 Survey of Investment Regulation of Pension Funds).

In the U.S., significant differences in regulation exist between corporate and public pension plans. U.S. public pension funds are subject to the Government Accounting Standards Board (GASB) guidelines for discounting liabilities. These guidelines allow U.S. public funds to base their liability discount rates on the expected rate of returns on their assets. As U.S. public fund boards are largely unconstrained in the proportion of their assets that can be invested in risky assets and in their assumptions on the expected rate of return in the various asset classes, this gives these boards very significant latitude to choose their liability discount rate. In particular, we argue that U.S. public funds have considerably more latitude in their choices than U.S. corporate funds or (public or corporate) funds in Canada and Europe.

Novy-Marx and Rauh (2009, 2011) and Brown and Wilcox (2009) argue that this latitude gives rise to strong incentives to invest more in risky assets that can be assumed to have higher expected rates of return. The resulting higher liability discount rates allow the public funds to present lower liability estimates and better funding status, even though the nature of their liabilities remains the same. In times that public funds are typically severely underfunded (even using their relatively high liability discount rates), this relieves pressure, at least in the short term, on the public entities involved, as well as on (again temporarily) politicians and taxpayers.

Despite the critiques from academic economists, GASB still maintains the view that "as long as plan assets related to current employees, retirees, and their beneficiaries are projected to be sufficient to make the projected benefit payments for those individuals, governments would discount projected benefit payments using the long-term expected rate of return" (GASB (2011)). Ambachtsheer (2010) argues that under this GASB rule, pension obligations will continue to be underfunded and underreported in U.S. public sector pension plans. Novy-Marx (2011) shows that under this rule it is possible that a plan can improve its official measure of funding status by *literally* burning money.[5]

[5] Novy-Marx (2011) shows that GASB penalizes a plan for holding cash and bonds, by forcing it to recognize a larger liability if they do so: "By destroying a dollar's worth of T-bills, or other cash-equivalents, a manager decreases a plan's assets, but increases the remaining assets' expected returns. These higher expected returns are used as a discounting rate and decrease the present value of plan's liability, as recognized by GASB, and this decrease can more than offset the loss of assets" (Novy-Marx (2011)). In the conclusion, we discuss the recent GASB (2011) proposals – pertaining only

Using time series data on the trends in strategic asset allocations over the last 20 years, we are able to test directly whether U.S. public pension funds use their freedom strategically. When facing decreasing bond yields, their typical discount rates of around seven to eight percent can only be maintained by allocating even more assets to equity and alternatives. This riskier allocation can thereby camouflage the level of underfunding. This camouflage of pension underfunding amplifies the risk that DB plans will run out of assets before they run out of liabilities, which would involve a significant wealth transfer from future to current generations of workers and taxpayers.

Pennacchi and Rastad (2011) document that state pension plans gamble by choosing a riskier portfolio following periods of relatively poor investment performance. We extend this analysis by associating changes in asset allocation to changes in fund maturity and government yields, contrasting U.S. public funds to U.S. corporate funds and international public and corporate pension funds, and over long time horizon (1990-2010).

Using yields on taxable municipality and treasury bonds, i.e. discount rates that reflect the very limited uncertainty of future public pension fund payments, Novy-Marx and Rauh (2011) show that all state pension plans in the U.S. are severely underfunded in 2009. The collective underfunding is in the range of $1.26–2.49 trillion. Hence, all public funds in U.S. are tempted to continue to use high discount rates even when interest rates decline, to present a more favorable situation to beneficiaries, taxpayers and creditors. Within the public U.S. funds, we expect that funds with a greater percentage of retired members have especially strong incentives to use higher discount rates, as the shorter maturity increases the present value of their liabilities and limits their ability to camouflage their underfunding. Hence, we expect that more mature public funds in the U.S. are using higher discount rates.

U.S. corporate funds face different regulatory standards and do not have clear incentives to invest more in riskier assets over time. Rauh (2009) shows that the risk management incentives to avoid costly financial distress dominate risk-shifting incentives in corporate defined benefit pension funds (especially amid tightening regulation). However, Love, Smith and Wilcox (2011) argue that various forms of government intervention, such as benefit guarantees, can alter this outcome dramatically by providing the firm with an incentive to shift risk to other parties.

---

to U.S. public funds – that would severe the link between liability discount rates and expected rates of returns but only for funds that can be classified as underfunded.

Most importantly for our empirical identification, individual firms in the U.S. have less discretion over their reported pension liabilities and discounting rates compared to public funds. In particular, until 2004 U.S. firms were required to discount their liabilities, for funding purposes and the estimation of the deficit reduction ("catch-up") contributions, using the 30-year Treasury rate. Since 2006 firms are allowed to discount their liabilities using a discount rate that is a blend of long-term corporate bonds, including both upper-medium and high-grade securities (Rauh (2006)).

At the same time, let us emphasize that we are making a comparison, and are not arguing that U.S. corporate plans had no regulatory latitude at all. For example, Brown (2008) presents examples of ways in which accounting standards that existed prior to the Pension Protection Act of 2006 allowed firms to hide the true economic costs of pension promises.[6] Since 2006, their asset-liability management has been subject to more regulatory scrutiny. Moreover, firms have also incentives to use appropriate discount rates and shore up underfunded pension plans, as firms that are sufficiently overfunded are exempt from the Pension Benefit Guaranty Corporation (PBGC) insurance premiums, and pension overfunding reduces the probability of a rating downgrade in such a way that the value of the firm is increased (Rauh (2006) and Bergstresser, Desai and Rauh (2006)).

In Canada, pension fund accounting standards generally require that the discount rate be selected based on market yields of high-quality corporate debt instruments with cash flows that match the timing and amount of expected benefit payments. These standards seem to leave only limited room for discretion, primarily in any latitude allowed on what "high quality" exactly means, which specific debt instruments are to be included, and how to address the lack of suitable debt instruments at very longer-term maturities (Canadian Institute of Actuaries (2011)).

Furthermore and in sharp contrast to the U.S., Canadian public and corporate pension plans are regulated in the same way, generally under the domain of the financial market supervisors of the Province where they are registered. In Canada, only the province of Ontario (where around 50 percent of the plans are registered) has established pension benefit insurance. Crossley and Jametti (2011) find that insured plans in

[6] For instance, prior to the adoption of Pension Protection Act of 2006 firms were only required to fund 90 percent of their liabilities, were permitted to "smooth" interest rates over four years (which allowed firms to report smaller liabilities in periods of declining interest rates), were allowed to use the smoothed "actuarial" value rather than the market value of plan assets (with up to a 20 percent deviation from actual market values permitted), and were allowed to avoid making cash contributions to their pension plan by making use of various accounting credits even if the plan was underfunded. The Pension Protection Act of 2006 addressed these issues by e.g. mandating minimum contribution rules that, after a phase-in period, are based on 100 percent, rather than 90 percent funding, of a plan's liabilities, and the time period for smoothing assets and liabilities was reduced to two years (Brown (2008)).

Canada invest about 5 percent more in equities than do similar plans without benefit guarantees. We do not have information on the province where Canadian funds are registered, but we control for fund fixed effects, which should absorb the differences in asset allocation due to such cross-jurisdiction variation.

Our small sample of European funds consists almost entirely of Dutch pension funds (plus a few from the U.K.). In the Netherlands, pension funds have almost no discretion in choosing their liability discount rate. Until 2004, Dutch pension funds were obliged to use 4% as their discounting rate. Afterwards, the Financial Assessment Framework (FTK), which is part of the Pensions Act, set the requirements to discount the liabilities with the term structure (swap-curve) of nominal risk-free interest rates (or real in case of inflation indexation guarantees). In this tight regulatory regime, poorly funded funds are less inclined to invest in riskier assets. If there is a funding shortfall (i.e., coverage ratio less than 105%), the fund must submit a recovery plan. The coverage ratio must regain the 105% level within 3 years. In the U.K., corporate plans discount their liabilities using AA yields, whereas public funds use a 3.0% discount rate, set based on the expected GDP growth in the long run.

3. Data

We can study the linkage between pension fund asset allocation and liabilities in a way that allows the consideration of both cross-sectional relations and relations within plans over time. We have access to the unique international CEM dataset that comprises more than 800 defined benefit pension funds for the 1990-2010 period. The CEM database provides a detailed perspective on the pension fund strategic (or target) asset allocations on a lower aggregation level. This detailed information enables us to precisely estimate the riskiness of the strategic asset allocation policy. Moreover, we can provide international evidence and examine the effect of different regulatory standards on the pension fund asset allocation, as our data covers three regions (U.S., Canada and Europe).

On the liabilities side, CEM provides information on the maturity of the fund, the indexation policy, and the liability discount rates. The dataset also contains information on the number of active and retired plan members, which enables us to infer the percentage of retired members. We use the percentage of retired members as a proxy of fund maturity. The database also provides information on the characteristics of the indexation policy, e.g. whether a fund provides full, ad hoc or no inflation protection. CEM also collects the discount rates that pension funds use to calculate the present value of the liabilities.

On the assets side, we especially focus on the percentage allocation to risky assets based on the reported strategic asset allocation policy. Every year, pension funds submit their target asset allocation policy and their actual (realized) asset allocation policy to CEM. In practice, the actual asset allocation policy can be affected by market movements due to expected transaction costs of rebalancing or inertia. For example, large positive returns on the equity market will increase the share of this asset class in the pension fund's actual asset allocation. Hence, in order to avoid the effects from market movements and to capture more precisely the decision of pension fund boards with respect to asset allocation, we focus on the strategic (target) asset allocation policy.[7]

We define the percentage allocation to risky assets as allocations to equity, alternative asset classes and risky fixed income investments. Alternative asset classes incorporate allocations to real estate, private equity, hedge funds, commodities, natural resources, infrastructure and tactical asset allocation mandates. We classify mortgages and high yield mandates as risky fixed income investments. The non-risky assets include investments in cash and investment-grade fixed income assets.

In our empirical analysis, we also split the sample into public and private pension funds. The private subsample captures the funds classified as 'corporate' and 'other' in the CEM database. In the U.S. and Canada, the 'other' category is mainly composed of multi-employer or Taft-Hartley funds, often referred to as 'union' funds. In Europe, the 'other' category covers mainly industry-wide funds, which are common in the Netherlands. We combine the category 'other' with 'corporate' and label this group as 'private' funds, because these pension funds are established by private sector employers and they are subject to the same regulation. For example, in the U.S., the multi-employer private defined benefit pension plans, like the single-employer plans, are regulated by the Employee Retirement Income Security Act (ERISA), and have an insurance program within the Pension Benefit Guaranty Corporation.

Table 1 presents the summary statistics of the pension funds in our sample. Panel A shows that the CEM database includes more than 800 funds and about 4,800 observations. The majority of the observations are U.S. pension funds, followed by Canadian pension funds and a smaller number of (mostly large) European pension funds. Pension funds included in the CEM database had more than $3.66 trillion of assets under management in 2010 and covered around 25 percent of global defined benefit pension fund assets

[7] All our results are robust to using the risky assets estimated based on the actual asset allocation policy instead of the strategic asset allocation.

(which is also more than 14 percent of total global pension fund assets).[8] Over the 1990-2010 period, the U.S. pension funds included in the dataset controlled more than 40 percent of total assets under management by the U.S. defined benefit pension fund sector. Canadian pension funds included in the CEM database held approximately 80-90 percent of the total assets under management by Canadian pension funds. To our knowledge, this is the broadest global database on pension fund asset allocation and performance available for academic research.

In Panels B and C of Table 1 we observe pension fund size, allocation to risky assets, maturity, liability discount rates and the percentage of pension funds providing contractual inflation protection over time. When analyzing the allocation to risky assets, we document different trends between public and private pension plans. The strategic allocation to risky assets of public pension funds has increased from 56.2 percent in 1993 to 70.1 percent in 2010, mainly due to increased risk-taking among U.S. public pension funds. Private pension plans have decreased their allocation to risky assets marginally: from 63.0 percent in 1993 to 62.1 percent in 2010. Panel A of Figure 1 presents that the allocation to risky assets among U.S. public pension funds has increased steadily over time, while among private funds it was rather stable until 2004 and decreasing thereafter. Additionally, we observe significant regional effects: Compared to Canadian and European pension funds, U.S. pension funds on average allocate a greater percentage of their assets to riskier investments.

Pension fund maturity summary statistics in Table 1 are estimated based retired members as a percentage of total plan members. We document that the vast majority of the pension funds are maturing over time and that private pension funds are generally more mature than public pension funds. The percentage of retired members among private plans has increased from 31.1 percent in 1993 to 52.2 percent in 2010, while among public pension funds the percentage of retired members has increased from 27.6 percent in 1993 to 38.9 percent in 2010. The difference in maturity between public and private funds can be explained by the fact that a growing number of U.S. corporations have chosen to freeze defined benefit (DB) pension plans and to replace them with defined contribution (DC) plans for new employees (see Rauh, Stefanescu and Zeldes (2011)). Hence, private DB pension plans in the U.S. mature faster than public funds, which is confirmed by Panel A of Figure 1 (% Retired). Panel B indicates that there is no difference in the

[8] The comparison is based on the Global Pension Assets Study 2011 conducted by Towers Watson. For more information, see: http://www.towerswatson.com/assets/pdf/3761/Global-Pensions-Asset-Study-2011.pdf.

percentage of retired members between public and private pension funds in Canada. In Europe, the sample is much smaller, but again we find no clear difference between public and private funds.

In Table 1, we also observe the percentage of pension funds providing contractual inflation protection to their members. In all three regions, public pension funds are significantly more likely to provide inflation protection as compared to private pension funds during the entire sample period. Interestingly, the percentage of U.S. public pension funds providing inflation protection has decreased slightly from 65.6 percent in 1993 to 56.3 percent in 2010.

In Table 1 and Figure 2, we also present the summary statistics of liability discount rates. U.S. pension funds are on average always using higher discount rates as compared to Canadian funds and, especially, compared to European pension funds. Figure 2 displays the trend in government bond yields and liability discount rates of public and private pension funds, separately for each region. Among U.S. funds, public pension funds are maintaining steady discount rates around 7.5–8.0 percent during the entire 1993–2010 period. In sharp contrast, the liability discount rates used by U.S. private pension funds are decreasing over time form 8.211 percent in 1993 to 5.723 percent in 2010, closely following the pattern in ten-year treasury yields. The discount rates used by Canadian pension funds are also decreasing over time, but not to the same extent as Canadian government bond yields. Most European funds use fixed discount rates of four percent before 2000, following strict regulatory guidelines. Afterwards, their liability discount rates move together with the government bond yields consistent with the revised guidelines (see the previous section for details). In both Europe and Canada, there is no significant difference between the discount rates used by public and private pension funds.

In order to extend the analysis on U.S. public pension funds, we merge the CEM database with the Comprehensive Annual Financial Reports (CAFRs) submitted by public pension funds in the U.S. as a source of information about the self-reported funding ratios and asset valuation methods of these pension funds. The majority of the additional data is obtained from the Center for Retirement Research at Boston College, but some data points are manually collected from the CAFRs. Figure 3 presents the trend in self-reported funding ratios of U.S. public pension funds during 1998–2010 period. Even though U.S. public pension funds on average employ higher liability discount rates than all other pension funds in our sample, most of the U.S. public funds are underfunded during the entire period. The average self-reported funding ratio decreases from 92 percent in 1998 to 75 percent in 2010. Overall, Figure 3 shows that the funding

problems of U.S. public pension funds are increasing over time and the vast majority of them are significantly underfunded in 2010, despite the use of a (too high) discount rate that is not in line with the riskiness of liabilities.

In addition to their large discretion in setting liability discount rates, U.S. public pension funds are also allowed to smooth asset valuations when reporting their funding ratios. Unlike the choice of higher liability discount rates which by construction always leads to higher funding ratios, smoothing asset valuations may not always result in better reported funding levels. However, smoothing asset valuations lowers the volatility of reported asset values across time, thereby enabling public pension funds to tolerate investments in volatile and risky assets more easily. Figure 3 shows that the majority of U.S. public pension funds smooth asset valuation across the last five years. Some pension funds use an even longer period of ten year smoothing of the assets. The figure further shows that the percentage of U.S. public pension funds using a smoothing is increasing over time, especially after 2008, which may be due to pension funds camouflaging the increased underfunding after the financial markets downturn: the percentage of U.S. public pension funds smoothing the asset valuation increases from 63% in 2001 to 68% in 2008 to 82 percent in 2010.

4. Pension fund investments in risky assets and asset valuation

We first explore how the strategic allocation to risky assets is related to pension fund maturity and other characteristics. In subsection 4.1 we focus on U.S. public pension funds and analyze the association of the changes in percentage allocation to risky assets and the changes in self-reported funding ratios. Subsection 4.2 analyzes how the allocation to risky assets influences the probability that U.S. public pension funds smooth the asset valuation

4.1 Pension fund maturity and risk taking

The standard deviations of our key variables of interest in Table 1 show that there is considerable variation in the allocation to risky assets and fund maturity among the pension funds. We relate the percentage allocation to risky assets based on the strategic asset allocation policy ($\%Risky_{i,t}$) to the percentage of retired members and other relevant pension fund characteristics using pooled panel regressions with year and regional, or fund fixed-effects:

$$\%Risky_{i,t} = \beta_1 \%Retired_{i,t} + \beta_2 Size_{i,t} + \beta_3 InfProt_{i,t} + \beta_4 Public_i + \beta_5 YD_t + FE_i + u_{i,t} \quad (1)$$

where $\%Retired$ refers to the percentage retired members and $Size$ is the logarithm of the US$ value of assets under management of fund *i* in year *t*. $InfProt$ is a dummy variable taking value one if fund *i* in year *t* provides contractual inflation protection and zero otherwise. $Public$ is a dummy variable taking value one if a pension fund is public and zero if the fund is non-public. YD is the year dummy, FE_i captures regional or fund-fixed effects and $u_{i,t}$ is the idiosyncratic error. We independently double cluster the robust standard errors in all regressions by pension fund and by year. In the regressions, we include interaction terms to capture the effect of public U.S. funds.

Table 2 presents the results of the allocation to risky assets panel regressions jointly for U.S., Canadian and European funds. Column (1) indicates that funds with a higher proportion of retired members, in line with theoretical predictions, invest less in risky assets. An increase in the percentage of retired members by 10 percent is associated with a reduction in the allocation to risky assets of 0.79 percent, controlling for fund size, the level of inflation protection and regional and year fixed effects. Controlling for fund-fixed effects in column (6), an increase in the percentage of retired members by 10 percent is associated with a reduction in the allocation to risky assets of 1.31 percent.

Pension funds with more assets under management (i.e., with larger 'fund size') allocate proportionally more assets to risky investments. In particular, a one-unit increase in the log of asset under management (i.e., doubling the pension fund size) increases the allocation to risky assets from 0.5–0.9 percent. The effect of fund size on the allocation to risky assets is not significant when controlling for fund-fixed effects in columns (6) – (8). This may be no surprise, as fund-fixed effects remove considerable variation and assets under management do not vary strongly over time (especially relative to the large cross-sectional variation in size and taking out year fixed effects). The decision to provide contractual inflation protection does not seem related to the asset allocation policy.

In column (2), we add a 'Public' dummy indicating whether the pension fund is public or not, in order to estimate the effect of plan type (public or private) on the strategic asset allocation policy. Public pension funds allocate 3.2 percent less to risky assets, on average. Column (5) and (8) show that U.S. public funds behave differently. In contrast to other funds, more mature U.S. public funds allocate *more* to risky

assets. The positive relation between fund maturity and risk taking is not consistent with the negative relation that is predicted by economic theory and found as the average coefficient in the overall sample in columns (1) – (8). Based on column (5), for all funds except U.S. public pension funds, a 10 percent increase in the percentage of retired members is associated with a 1.16 percent lower allocation to risky assets. However, a 10 percent increase in the percentage of retired members of U.S public funds is associated with a 2.05 percent increase in the allocation to risky assets (0.1 * (-0.116) + 0.1 * 0.321=0.0205). The magnitude is slightly smaller, but still positive and significant, when controlling for fund-fixed effects in column (8).

The large negative coefficients on the dummies for Canadian and European funds indicate significant regional differences in the allocation to risky assets, which seem unrelated to incorporating differences for U.S. public funds (comparing column (1) to columns (2) – (5)). Controlling for maturity, fund size and plan type, U.S. funds allocate around eight percent more to risky assets than Canadian funds, and 14 percent more than European funds.

The main conclusion from Table 2 is that more mature pension funds generally allocate fewer assets to risky investments, the only exception being U.S. public pension funds. Contrary to the predications from economic theory that maturing pension funds should reduce their exposure to risky assets, we find that mature U.S. public pension funds allocate a larger percentage of their assets to risky investments.

In Table 3, we analyze the relation between fund maturity and risk-taking for every region separately as a robustness check (especially regarding the triple interaction in Table 2).[9] We find a significant negative relation, on average, between fund maturity and risk taking in the U.S. and the Canadian sample. For U.S. funds (see Panel A, columns (3) and (5)), we find that a 10 percent increase in fund maturity is associated with a reduction of the allocation to risky assets of 1.43 – 1.76 percent among private pension funds. However, for U.S. public funds this relation is positive. In particular, based on column (3), a 10 percent increase in the percentage of retired members is associated with an increase of the allocation to risky assets of a U.S. public pension fund by 2.31 percent (0.1 * (-0.143) + 0.1*0.374). When controlling for fund-fixed effects in column (5), a 10 percent increase in the percentage of retired members is associated with an increase of the allocation to risky assets of a U.S. public fund by 1.10 percent.

Results for Canada (Panel B of Table 3) show that an increase of 10 percent in fund maturity reduces the allocation to risky assets by 0.8–0.9 percent. Whether a plan is private or public seems unrelated to the

[9] We do not show results for European funds separately due to its limited sample size.

strategic asset allocation policy of Canadian pension funds. Public and corporate pension funds in Canada are also reducing their exposure to risky assets in a similar way as they mature.

During 1990–2010, yields on government bonds continuously declined in all regions (see Figure 2). For example, the yield on ten-year U.S. Treasury notes decreased from 8.55% in 1990 to 3.22% in 2010. In order to investigate whether these decreasing treasury yields have an effect on the allocation to risky assets, we also add the ten-year treasury yield in the previous year to the model presented in equation (1). Table 4 examines whether declining yields, as a proxy for the expected return on non-risky assets like cash and government bonds, influence the allocation to risky assets by pension funds. Our results indicate that only public funds, and especially U.S. public funds, increased their allocation to risky assets as a response to declining government bond yields.

Controlling for fund-fixed effects in columns (5) – (8), the association between the government bond yield and the allocation to risky assets remains statistically significant only for U.S. public pension funds. According to column (7), for U.S. public funds the about five percentage point decline in the yield on ten-year Treasury securities over this period is associated with a 14 percentage points increase in the allocation to risky assets (5 * [-1*(-0.010) + (-1)*(-0.018)]). This finding is robust to controlling for the percentage of retired members in columns (4) and (8).

Summarizing, we show that more mature funds invest less in risky assets, the only exception being U.S. public pension funds. Moreover, especially these funds take more risk in response to declining government bond yields. The increased risk-taking by U.S. public funds when faced with low interest rates is particularly remarkable as U.S. public funds have even less ability (relative to e.g. U.S. private funds) to scale back spending if risky assets underperform expectations, as their promised benefits often have special protections in state constitutions as well as through statutory and common law (see Brown and Wilcox (2009)).

4.2 Self-reported funding ratios of U.S. public pension funds and allocation to risky assets

So far, we have seen that U.S. public pension funds are different from all other public and private pension funds in our sample, and that more mature U.S. public funds allocate a larger share of their assets to risky investments. We extend the analysis on the risk-taking decisions of U.S. public pension funds by focusing on the effect of underfunding on the allocation to risky assets. Incorporating the levels of self-

reported funding ratios directly in the analysis is problematic as these funding ratios can be influenced significantly by pension funds through choosing higher liability discount rates or by using smoothed asset valuations. These two valuation decisions are stable over time, which implies that the level of self-reported funding ratios may not show precisely the pension fund underfunding problems, whereas changes in funding ratios will present more realistically the heterogeneity in funding problems across U.S. public funds. Hence, we focus on the effect of lagged changes in self-reported funding ratio on the changes in allocation to risky assets.

Table 5 shows that lagged changes in self-reported funding ratios have a negative effect on changes in the allocation to risky assets. The cumulative change in self-reported funding ratios captures the changes over the previous two years: from year *t-2* to year *t*. The mean cumulative change in self-reported funding ratios is a decline of 3.45 percent, which leads to 15 basis points (-0.042 * 0.0345) increase in the strategic allocation to risky assets. The average annual change in allocation to risky assets among U.S. public funds is 109 basis points, so changes in self-reported funding ratios predict a significant part of the changes in the allocation to risky assets. The results in models (4) – (6) show that the economic magnitude of this relation doubled in the last five years of our sample period, when the U.S. public pension funds underfunding increased substantially. In this sub-period an average cumulative decrease in the self-reported funding ratios results in an increase of about 30 basis points in the allocation to risky assets. Our results indicate that U.S. public pension funds responded to the deteriorating funding situation by taking more risk.

4.3 Asset valuation smoothing

Figure 4 shows that the majority of U.S. public pension funds use a smoothing period when valuing the assets. Actuarial guidelines allow wide discretion in valuation methods (see Actuarial Standard Board (2007, 2009)) and also vary by state. For example, the State of New Jersey's Public Employees' Retirement System values assets by their average market value over the last five years.[10] While the figure shows that New Jersey's example is typical in its use of a five-year smoothing period, some pension funds use up to ten years to smooth the asset valuation. Smoothing asset valuations reduces the reported volatility in investment performance, which in turn may enable the pension fund to better tolerate the volatility of risky investments, present more stable self-reported funding ratios and keep the contribution level constant even in periods of

[10] See http://www.nj.gov/treasury/pensions/annrpt2011/pers11.pdf, page 24.

large market volatility. In Table 6, we estimate the probability that U.S. public pension funds uses a smoothing period in their asset valuation with the following logit model:

$$Pr(Smoothing_{i,t} = 1|X) = F(\delta_1 \%Risky_{i,t} + \delta_2 Return_{i,t-1} + \delta_3 Z_{i,t} + \epsilon_{i,t}), \quad (2)$$

where F is a logit function taking on values strictly between zero and one and $Smoothing_{i,t}$ is a binary dependent variable. The dependent binary variable is 0 if a U.S. public pension fund *i* does not smooth asset valuations in year *t* and equals 1 otherwise. We model the probabilities as a function of pension fund characteristics, focusing on the strategic allocation to risky asset classes ($\%Risky_{i,t}$) of fund *i* in year *t*. We control for the lagged pension funds returns ($Return_{i,t-1}$). When examining the role of performance, we investigate the effect of prior year net returns of the fund, lagged U.S. equity market returns and the prior year net benchmark-adjusted returns of the fund. $Z_{i,t}$ captures other control variables, such as lagged changes in the allocation to risky assets, the percentage retired members, fund size and inflation protection. In all regressions, we include year dummies and independently double cluster the robust standard errors by pension fund and by year.

For funds with an average allocation to risky investments (72%), the probability that a fund is smoothing asset valuations equals 73.71 percent. The logit regression results indicate that U.S. public funds with a higher allocation to risky assets are more likely to smooth asset valuations.[11] For example, the probability to smooth asset valuations for pension funds with 64% (one standard deviation decrease relative to the mean) allocation to risky assets is 62.09 percent. The probability to smooth asset valuations increases to 82.75 percent for U.S. public pension funds allocate 79% (one standard deviation increase) to risky assets.

Lagged net returns and lagged equity market returns are not significantly related to the smoothing probability. However, the previous year net benchmark-adjusted returns are significantly negatively related to the probability that the fund employs asset valuation smoothing. That suggests that U.S. public pension funds that recently moved to smoothing asset valuations in response to relative underperformance, compared to their benchmarks and peers, rather than as a response to declining asset market values per se. According to model (5), the probability to use smoothing if pension funds outperform their benchmarks on a net basis by

[11] Smoothing will matter most for U.S. public pension funds investing a greater share of their assets in public equity. Returns in alternative assets are naturally smoothed as these assets are traded on private markets and pension funds do not really need the additional smoothing period.

219 basis points (one standard deviation change) is 70% percent. This probability increases to 74% if pension funds have zero net benchmark-adjusted returns and increases further to 78% if U.S. public pension funds underperform their benchmarks net of costs by 219 basis points (a one standard deviation change).

5. Pension fund liabilities valuation

In this section, we analyze the valuation and composition of pension fund liabilities. The next subsection discusses the relation between liability discount rates and pension fund maturity and risk-taking. Subsection 5.2 analyzes the probability that U.S. public pension funds provide contractual inflation protection to their members.

5.1 Liability discount rates

This subsection explores whether the liability discount rates reported to CEM are related to certain pension fund characteristics. We focus on the relation of fund maturity and risky asset allocation with the discount rate used by pension funds to value their liabilities. We estimate the following pooled panel regression model with year and regional, or fund-fixed effects:

$$LDR_{i,t} = \gamma_1 \%Risky_{i,t} + \gamma_2 \%Retired_{i,t} + \gamma_3 Size_{i,t} + \gamma_4 InfProt_{i,t} + \gamma_5 Public_i + \gamma_6 YD_t + FE_i + u_{i,t}, \quad (3)$$

where $LDR_{i,t}$ represents the liability discount rate of fund *i* in year *t* and $u_{i,t}$ are idiosyncratic errors.

Results in Table 7 show that the allocation to risky assets is positively related to the liability discount rates. In columns (1) and (8), we document that an increase in the allocation to equity, alternative assets and riskier fixed income assets is associated with a higher liability discount rate. Further, more mature pension funds are using lower discount rates, which is in line with economic theory.

We observe substantial regional differences in the liability discount rates. Canadian pension funds are using rates to discount their liabilities that are 30.9–58.6 basis points lower as compared to U.S. funds. European funds are using liability discount rates more than 300 basis points lower relative to their U.S. counterparts, which is consistent with the regulatory differences.

Whether a pension fund is public or private has a very strong effect on the liability discount rate in the U.S. Column (3) indicates that U.S. public funds are typically using discount rates that are 64 basis points

higher than U.S. corporate funds. In Canada and Europe, plan type is not affecting the liability discount rates, i.e. in those regions public and corporate funds are behaving in a similar way (see the insignificant coefficient on the 'Public' dummy in columns (3), (5) and (7)).

According to column (5), U.S. public funds that allocate a larger percentage of their assets to risky investments tend to use higher liability discount rates. Surprisingly, an even more important determinant of the liability discount rate among U.S. public pension funds is fund maturity. Contrary to what economic theory would predict, more mature public pension funds in the U.S. are using even higher discount rates. In particular, the interaction term %Retired * Public * U.S. is positive and statistically significant. Hence, based on column (7), for U.S. public pension funds, a 10 percent increase in the percentage of retired members is associated with an increase of the discount rate by 21 basis points (0.1 * (-0.299) + 0.1 * 2.393). Controlling for fund-fixed effects in column (12), this economic magnitude increases to 31 basis points.[12]

In summary, our results show that pension funds that invest in riskier assets typically use higher rates to discount their liabilities. More mature funds in Europe, Canada and more mature private funds in the U.S. use lower liability discount rates. However, in sharp contrast more mature U.S. public pension funds are using the highest discount rates during 1990–2010 period.

In Table 8, we estimate the association of interest rates and liability discount rates using pooled panel regressions by adding the 10-year government bond yields instead of year dummies. Brown and Wilcox (2009) and Novy-Marx and Rauh (2011) argue that liability discount rates should be based on the nominal (or real, if inflation protection is offered) treasury yields, municipal interest rates or swap rates.[13] Consistent with their typical regulation, we find that discount rates are strongly positively associated to yields. The average response is less than proportional, as a 100 basis point decrease in the ten-year government bond yield is associated with a decrease in the liability discount rate of around 30–40 basis points. Even when controlling for treasury yields, the percentage of retired members remains negative and significant, especially when controlling for fund-fixed effects. More mature pension funds are using lower

[12] As a comparison and based on column (7), a 10 percent increase in the percentage of retired members is associated with a reduction of the discount rates of three basis points among private funds in the U.S. and all fund types in other regions.

[13] Novy-Marx and Rauh (2011) find that the effective average duration of U.S. public state funds over the range of various discount rates is roughly 13 years. We examine whether the liability discount rates follow the trend in ten-year treasury yields in U.S., Canada and Europe (consistent with the duration of liabilities). We use the ten-year treasury rate, because the fifteen-year treasury rate is not available in all regions covered by our study and in our estimations we are focused on the trend in treasury yield, which is highly correlated across treasury yields of different maturities.

discount rates regardless of the trend in treasury yields. The percentage allocation to risky assets also remains positive and significant.

In sharp contrast and consistent with the trend in Panel A of Figure 2, the liability discount rates used by U.S. public pension funds are not responding to changes in Treasury yields. The triple interaction term Public * Yield * U.S. is negative and significant, outweighing completely the unconditional effect of treasury yield on discount rates. Based on column (8), a 100 basis point decrease in the treasury yield reduces the discount rate for U.S. public funds by around four basis points only (1 * 0.297 + 1 * (-0.251)), which is not significantly different from zero.

Next, we perform a robustness check to examine the relation between liability discount rates and pension fund characteristics by region. Results in columns (1) to (4) in Table 9 confirm that U.S. private pension funds use lower liabilities discount rates when treasury yields decline and that more mature private pension funds in the U.S. are using significantly lower discount rates. Consistent with Tables 7 and 8, U.S. public pension funds are behaving in the opposite way. We find no such differences between public and non-public funds for Canada in columns (5)–(8).

Overall, the results indicate that U.S. public funds are not only using higher discount rates if they are more mature, but also that U.S. public funds do not take into account the changes in treasury yields when determining their discount rates, contrary to economic theory. Instead, regulations proscribe U.S. public funds to set their liability discount rate equal to the expected return of the asset portfolio, where they have great latitude to posit what those expected returns are. As a result, another interpretation of the lack of any association between the level of interest rates and the liability discount rates of U.S. public funds – while controlling for the percentage allocated to risky assets – is that U.S. public pension funds have made the economically surprising choice of not lowering their expected return estimates on risky assets (in nominal terms) as interest rates decline.

Table 10 explore furthers the heterogeneity in liability discount rate decisions among U.S. public pension funds by considering their relation with self-reported funding ratios. Although increasing the liability discount rate should mechanically increase the funding ratio (as using a higher discount rate reduce the present value of liabilities while not affecting asset values), we document that U.S. public pension funds with lower self-reported funding ratios use *higher* liability discount rates. The negative association between liability discount rates and self-reported funding ratios suggests that better funded public pension funds

engage in less camouflaging behavior, while camouflage is more prevalent among the pension funds with greater underfunding problems. Economically, a 10 percent decrease in the self-reported funding ratio is associated with an increase in the liability discount rate of around 11–14 basis points. As shown in column (6) and (7) that only use data for 2006–2010 when underfunding problems have become more severe, the economic association in these last five years has become stronger: a 10 percent decrease in the self-reported funding ratio results in an increase in the liability discount rate of around 20–22 basis points.[14] We thus conclude that it is likely that the self-reported funding ratios more realistically reflect the funding situation of relatively better funded U.S. public pension funds and mask relatively more the underfunding problems among poorly funded U.S. public pension funds.

5.2 Inflation protection

Next, we estimate the probability that a pension fund provides contractual inflation protection to its participants. We model these probabilities as a function of pension fund characteristics, focusing on fund maturity, fund size and plan type (public or private). To answer this question we use a binary response logit model:

$$Pr(InfProt_{i,t} = 1|X) = F(\theta_1 \%Ret_{i,t} + \theta_2 Size_{i,t} + \theta_3 Public_i + \theta_4 Region_i + \theta_5 YD_t + \varepsilon_{i,t}) \quad (4)$$

where F is a logit function taking on values strictly between zero and one. $InfProt_{i,t}$ is a binary dependent variable equal to 0 if a pension fund *i* does not provide contractual inflation protection in year *t* and 1 otherwise.

Our results in Table 11 indicate that the likelihood that public funds provide contractual inflation protection is significantly higher than for non-public funds. Results in column (2) show that the probability that a private fund provides contractual inflation protection is 17.0 percent, whereas the probability for public pension funds is 58.7 percent. Column (3) shows that U.S. public funds have the highest probability to provide inflation protection among the pension funds in our sample.

In columns (1) and (2) of Table 11, we also document that funds with a greater percentage of retired members are less likely to provide contractual inflation protection. For instance, based on column (2), the

[14] In unreported results, we document that the relation between self-reported funding ratios and liability discount rates is robust to the inclusion of fund fixed effects.

probability to provide contractual inflation protection for funds with 27 percent retired members (25^{th} percentile) is 32.0 percent. This probability decreases to 25.9 percent for funds that have 48 percent retired members (75^{th} percentile). Fund maturity has a negative effect on the probability to provide contractual inflation protection by U.S. funds (the relation is negative, but insignificant among Canadian funds).

The negative relation between the percentage of retired members and the decision to provide contractual inflation protection indicates that 'younger' pension funds may overpromise to their plan members. The risk younger cohorts face is that, once pension funds mature and face funding difficulties in delivering the promised benefits, contractual inflation protection may be removed from the pension deal. Eliminating the contractual inflation protection is one of the measures of last resort available to underfunded pension funds, but its implementation is difficult especially in the U.S. context, as pension benefit promises have strong protections.

Furthermore, even after controlling for fund maturity, size and plan type, the likelihood that Canadian funds provide inflation protection is significantly higher. Our results also indicate that, in Canada, larger funds are more likely to provide inflation protection. Based on columns (8), (9) and (10), a one unit increase in the logarithm of assets under management (i.e., doubling the fund size) increases the probability that a Canadian pension fund provides contractual inflation protection by 11.9–13.2 percent.

In the previous section, we showed that public pension funds use substantially higher liabilities discount rates. The results in Table 11 indicate that public pension funds are more generous as they are more likely to promise contractual inflation protection to their beneficiaries. Brown and Wilcox (2009) argue that, if a pension fund promises inflation protection, then their liabilities should be discounted using real interest rates, i.e., inflation-indexed rates based on the Treasury Inflation-Protected Securities (TIPS). Hence, public pension funds do not only ignore the trends in Treasury yields, but also the promised inflation protection to their beneficiaries when determining the liability discount rates.

6. Performance

In the previous sections, we documented that U.S. public pension funds have behaved differently from all other pension funds by increasing allocations to risky assets, despite the maturing member population and decreasing treasury yields. While we have argued that this is driven by their distinct regulations, an alternative hypothesis is that U.S. public pension funds collectively have become more

positive about their skills or the investment opportunities in risky assets (irrespective of the incentives arising from their regulation linking liability discount rates to the expected returns on their assets). In this section, we examine whether pension fund returns justify their preference for a riskier asset allocation policy.

We calculate net benchmark-adjusted returns separately for each asset class by subtracting the total investment costs and the return from the self-reported benchmark (in that asset class) from the gross returns, and then aggregate up across all asset classes held by the fund. We relate the net benchmark-adjusted returns ($NTR\_BM_{i,t}$) of fund i in year t to fund characteristics, such as the percentage of retired members ($\%Retired_{i,t}$), percentage allocation to risky assets ($\%Risky_{i,t}$), lagged changes in percentage allocation to risky assets ($\Delta\%Risky_{i,t-1}$) and other pension fund characteristics ($X_{i,t}$), using pooled panel regressions with year (YD_t) and regional, or fund fixed-effects (FE_i):

$$NTR\_BM_{i,t} = \rho_1 \%Risky_{i,t} + \rho_2 \Delta\%Risky_{i,t-1} + \rho_3 \%Retired_{i,t} + \rho_4 X_{i,t} + \rho_5 Public_i + \rho_6 YD_t + FE_i + \nu_{i,t} \quad (1)$$

$Public$ is a dummy variable taking value one if a pension fund is public and zero if the fund is private and in the regressions we include also interaction terms to capture the effect of public U.S. funds, as the group with significantly different regulation. We independently double cluster the robust standard errors in all regressions by pension fund and by year.

Results in Table 12 show that the percentage of retired members and allocation to risky assets are generally not related to the pension fund net benchmark-adjusted returns. In column (2), we add a public dummy variable and document that public pension funds underperform as compared to private funds by 24 basis points. Column (3) shows that this underperformance among public pension funds is due solely to U.S. public pension funds, which underperform by 59 basis points annually on a net benchmark-adjusted basis. There is no significant difference in the performance of Canadian (and European) public versus private pension funds.[15]

In columns (5) and (7), we document that there is substantial heterogeneity in the net benchmark-adjusted returns of U.S. public pension funds determined by two main factors: the allocation to risky assets and fund maturity. U.S. public pension funds with a greater allocation to risky assets underperform more. A 10 percent increase in the strategic allocation to risky assets of U.S. public pension funds is associated with

[15] Interestingly, we control for European and Canadian pension funds using regional dummy variables, but we do not find significant regional performance effects.

an increase in the underperformance of 11 basis points annually. In column (6), we find that more mature public pension funds underperform, but this underperformance is mainly due to the returns of U.S. public pension funds. Based on column (7), a 10 percent increase in the percentage of retired members of U.S. public funds results in an underperformance of 8 basis points compared to all other pension funds. In columns (8) – (11) we add controls for the previous year net benchmark-adjusted performance and for the lagged changes in allocation to risky assets.[16] Even when controlling for the lagged changes in allocation to risky assets, U.S. public pension funds underperform by 67 basis points compared to other pension funds.

In Table 13, we explore further the underperformance of U.S. public pension funds by controlling for fund fixed effects and risk-adjusting the returns. We risk-adjust the net benchmark-adjusted returns using a five-factor model that includes the excess equity market return, SMB, HML, momentum factor and the Pastor and Stambaugh (2003) traded liquidity factor. Results in columns (3) and (4) show that, on a risk-adjusted basis, the percentage of retired members has an even stronger effect on the performance. Among U.S. public funds, a 10 percent increase in the percentage of retired members is associated with a decrease of the annualized abnormal returns of 38-48 basis points. In addition, the lagged changes in the allocation to risky assets also maintain the significant negative effect on performance.

In summary, our results show that U.S. public pension funds underperform and this underperformance is greater among more mature U.S. public plans and those with a higher strategic allocation to risky assets.

7. Conclusion

In this paper, we employ a comprehensive dataset of U.S., Canadian and European public and corporate defined benefit pension funds and investigate their asset allocation, liability discount rates and contractual inflation protection over the last two decades. We find that U.S. public pension funds behave different from all other pension funds and not in line with economic theory. We ascribe their different reaction to the maturing of their participant base and declining government bond yields to opaque incentives arising from their distinct regulatory framework that gives U.S. public pension funds wider discretion to

[16] Pension funds with greater increases in strategic allocation to risky assets in year t-1, underperform compared to their peers in year t. If a pension funds increased the allocation to risky assets by 10 percent in the previous year, than it has 17 to 20 basis points lower net benchmark-adjusted performance this year. We hence observe that a rapid increase in the exposure to risky assets results in underperformance, which implies that pension funds should build their riskier allocations gradually. This effect is not specific to U.S. public pension funds, but observable across all pension funds in our sample.

choose their liability discount rates than U.S. corporate funds and both public and private pension funds in Canada and Europe.

Generally, more mature pension funds invest less in risky assets and use lower discount rates for the valuation of their liabilities. Canadian and European public and private funds, as well as corporate pension funds in the U.S., base their liability discount rates on high quality interest rates. However, U.S. public pension funds are allowed to base their discount rates on the expected rate of return of their asset portfolio, which provides them with incentives to take more risk over time in response to declining government bond yields. Taking more risk thus enables public pension funds in the U.S. to maintain high discount rates and present more favorable funding ratios to the public, despite the fact that this does not in any way alter the nature of their liabilities. For public U.S. funds, we document that funds with a greater percentage of retired members use even higher discount rates, possible because the shorter maturity increases the present value of their liabilities and limits their ability to camouflage their underfunding.

Gradually, U.S. public funds have become the biggest risk-takers among pension funds around the globe, especially if they are more mature or the proportion of their members that is retired increased more. These funds are thus exposed to very large market risk. At the same time, U.S. public funds have almost no ability to scale back spending if risky assets underperform expectations, as their benefits are often given special protections in state constitutions as well as through statutory and common law (Brown and Wilcox (2009)).

The increased risk-taking of U.S. public pension funds is associated with poorer investment performance. On average, U.S. public pension funds underperform their benchmarks by about 60 basis points annually more than other pension funds. Underperformance is more severe for more mature funds as well as those with larger allocations to risky assets. As a result, the average self-declared funding ratio of U.S. public pension funds, which is based on high liability discount rates and smoothed asset valuation, has reached the lowest level in 2010 and is equal to 75 percent. Hence, a major worry is that their increased risk-taking is reckless and could lead to substantial future costs to taxpayers or public entities if their more volatile risky investments fail to meet the expected rates of return. Moreover, the lack of any association between liability discount rates and contractual inflation protection (which applies particularly to U.S. public funds) raises the concern that these funds may underestimate even more the costs of these promises. This raises the possibility that U.S. public funds are camouflaging the real costs of pension promises made to their

beneficiaries and taxpayers. The economic consequences of these practices could involve material wealth transfers from future taxpayers and workers to current pensioners and workers (see also Kocken (2012)).

In conclusion, we show that the regulatory framework may have a substantial impact on the strategic decisions made by pension funds. We provide evidence that the distinct behavior of U.S. public pension plans is consistent with their more lax regulatory context, which may provide the wrong incentives. In times of severe underfunding or political distress, the incentives are strong to not lower discount rates sufficiently in response to lower interest rates and a maturing member base, at the same time adopting (perhaps recklessly) risky asset allocation strategies and camouflaging the real costs of pension promises made to their beneficiaries and taxpayers. As a result, their regulation allows a potentially severe conflict of interest between current and future stakeholders.

The policy implications are clear but challenging. The purpose of public and private defined benefit pension plans is the same, i.e., providing a secure and affordable pension to their members. There seems to be no good economic reason why public and private pension funds in the U.S. should be regulated in a different way. When corporate and public funds are regulated in a similar way, i.e., in Canada and Europe, their behavior does not differ. Our findings indicate that in a highly politicized setting and a tough economic environment for pension funds in general, U.S. public pension funds willingly made strategic decisions to significantly increase risk and camouflage the value of their promised pension benefits. These decisions have a large negative impact for future stakeholders and taxpayers through lower returns and masked funding problems. In sum, we argue that U.S. policy pertaining to public pension funds needs drastic reform and to be brought in line with regulations pertaining to U.S. private pension funds, as current laws and regulations effectively exempt states and cities from behaving prudently in how they manage and disclose the financing of pension systems of their employees.

Recently, the GASB issued new proposals that take a major step in this direction. Specifically, GASB (2011) proposes severing the link between liability discount rates and expected rates of returns but *only* for funds that can be classified as underfunded, i.e. where the plan assets are *not* "projected to be sufficient to pay benefits and the net position projected to remain after each benefit payment can be invested long-term." The GASB notes that for such underfunded funds where "the plan assets are projected not to be available to be invested long-term and, therefore, would be insufficient for paying benefits to current employees, retirees, and their beneficiaries, … the projected benefit payments take on attributes that are

similar to other forms of debt. In this circumstance, governments would incorporate into the discount rate a tax-exempt, high-quality 30-year municipal bond index rate to reflect that future benefit payments are not expected to be made from long-term investments. High quality would be defined as being rated AA or higher (or an equivalent rating).” However, for funds where plan assets are projected to be sufficient, the wrong incentives would remain in place as the assumed rate of returns of the assets could still be used to discount the liabilities. Moreover, these projections (of whether or not assets are sufficient to pay the benefits) can seemingly still be based on liability discount rates that are linked to expected asset returns. As a result, the new GASB proposals would create even stronger incentives to camouflage liabilities and engage in reckless risk-taking for funds that are close to being underfunded (and that may indeed be underfunded if liabilities would be discounted at – currently – lower high-quality municipal yields) and that rationally want to avoid being classified as underfunded.

References

Allen, F. (2001): "Presidential Address: Do Financial Institutions Matter?," *The Journal of Finance*, 56(4), 1165-1175.

Ambachtsheer, K. (2010): "GASB's Folly," The Ambachtsheer Letter, August.

Andonov, A., R. Bauer, and M. Cremers. (2011): "Can Large Pension Funds Beat the Market? Asset Allocation, Market Timing, Security Selection and the Limits of Liquidity," *Working Paper*, Maastricht and Yale University.

Andonov, A., P. Eichholtz, and N. Kok (2012): "Value Added from Money Managers in Private Markets? An Examination of Pension Fund Investments in Real Estate," *Working Paper*, Maastricht University.

Benzoni, L., P. Collin-Dufresne, and R. Goldstein (2007): "Portfolio Choice Over the Life-Cycle when the Stock and Labor Markets are Cointegrated", *Journal of Finance*, 62(5), 2123–2167.

Bergstresser, D., M. Desai, and J. Rauh (2006): "Earnings manipulation, pension assumptions, and managerial investment decisions," *Quarterly Journal of Economics*, 121(1), 157–195.

Boudoukh, J., and M. Richardson (1993): "Stock returns and inflation: a long horizon perspective," *American Economic Review*, 83, 1346–1355.

Brown, J. (2008): "Guaranteed Trouble: The Economic Effects of the Pension Benefit Guaranty Corporation," *Journal of Economic Perspectives*, 22(1), 177–198.

Brown, J., and D. Wilcox (2009): "Discounting State and Local Pension Liabilities," *American Economic Review*, 99(2), 538-542.

Campbell, J.Y., and L.M. Viceira (2005): "The term structure of the risk-return trade-off," *Financial Analysts Journal*, 61, 34–44.

Canadian Institute of Actuaries (2011): "Accounting Discount Rate Assumption for Pension and Post-employment Benefit Plans", Educational Note, Issued September 20, 2011.

Crossley, T., and M. Jametti (2011): "Pension Benefit Insurance and Pension Plan Portfolio Choice," *forthcoming in Review of Economics and Statistics*.

Dyck, A. and L. Pomorski (2011): "Is Bigger Better? Size and Performance in Pension Plan Management," *Working Paper*, University of Toronto.

French, K. (2008): "Presidential Address: The Cost of Active Investing," *Journal of Finance*, 63(4), p.1537-1573.

Governmental Accounting Standards Board (2011): "Pension Accounting and Financial Reporting, Plain-Language Supplement to an Exposure Draft."

Kocken, T. (2012): "Pension Liability Measurement and Intergenerational Fairness," *Rotman International Journal of Pension Management*, 5(1).

Love, D.A., P.A. Smith, and D.W. Wilcox (2011): "The effect of regulation on optimal corporate pension risk," *Journal of Financial Economics*, 101, 18–35

Lucas, D., and S.P. Zeldes (2006) "Valuing and Hedging Defined Benefit Pension Obligations: The Role of Stocks Revisited," *Working Paper*, Northwestern and Columbia University.

Lucas, D. and S.P. Zeldes (2009): "How should public plans invest?," *American Economic Review*, 99(2), 527-532.

Novy-Marx, R., and J. Rauh (2009): "The Liabilities and Risks of State-Sponsored Pension Plans." *Journal of Economic Perspectives*, 23(4), 191–210.

Novy-Marx R. and J. Rauh (2011): "Public Pension Promises: How Big Are They and What Are They Worth?," *The Journal of Finance*, 66(4), 1211–1249.

Novy-Marx (2011): "Logical Implications of GASB's Methodology for Valuing Pension Liabilities," *Working Paper*, University of Rochester and NBER.

OECD Secretariat (2011): "Survey of Investment Regulation of Pension Funds", Published June 2011.

Pennacchi, G., and M. Rastad (2011): "Portfolio Allocation of Public Pension Funds," *Journal of Pension Economics and Finance*, 10(2), 221-245.

Rauh, J. (2006): "Investment and Financing Constraints: Evidence from the Funding of Corporate Pension Plans," *The Journal of Finance*, 61(1), 33–71.

Rauh, J. (2009): "Risk Shifting versus Risk Management: Investment Policy in Corporate Pension Plans," *Review of Financial Studies*, 22, 2687-2733.

Rauh, J., I. Stefanescu, and S. Zeldes (2011): "Cost savings and the freezing of corporate pension plans," *Working Paper*, Northwestern, Indiana and Columbia University.

Schotman, P.C., and M. Schweitzer (2000): "Horizon sensitivity of the inflation hedge of stocks," *Journal of Empirical Finance*, 7, 301–315.

Sundaresan, S., and F. Zapatero (1997): "Valuation, Optimal Asset Allocation and Retirement Incentives of Pension Plans," *Review of Financial Studies*, 10, 631–60.

Table 1: Summary statistics

This table provides descriptive statistics of pension fund asset allocation, maturity, liability discount rates, fund size and inflation protection. In Panel A, rows # Funds and # Obs. present the number of funds and observations. In Panels B and C, we show the means and standard deviations (in parentheses) of variables separately in 1993 and 2010. %Risky 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), high yield bonds and mortgages. %Retired presents the average percentage of retired members from total plan members. LDR presents the average liability discount rates used by the pension funds. Fund size row reports the average total assets under management (in billion US$) of the pension funds. Inflation protection row shows the percentage of funds providing contractual inflation protection. We show the statistics for all funds and separately by region. We also report the statistics separately for public and private (corporate) funds.

	All funds		**U.S.**		**Canada**		**Europe**	
	Public	Private	Public	Private	Public	Private	Public	Private
Panel A: Total number of pension funds and observations								
# Funds	226	593	160	348	57	177	9	68
# Obs.	1653	3168	1171	1761	448	1173	34	234
Panel B: Summary statistics in 1993								
# Obs.	37	148	32	84	5	64		
%Risky	0.562	0.630	0.567	0.665	0.531	0.585		
	(0.177)	(0.126)	(0.187)	(0.135)	(0.101)	(0.097)		
%Retired	0.276	0.311	0.287	0.322	0.205	0.296		
	(0.107)	(0.160)	(0.104)	(0.167)	(0.112)	(0.151)		
LDR	7.742	7.986	7.621	8.211	8.400	7.695		
	(1.238)	(0.881)	(1.298)	(0.782)	(0.548)	(0.921)		
Fund size	8.772	2.278	8.998	3.401	7.323	0.804		
	(14.686)	(5.826)	(15.422)	(7.488)	(9.727)	(1.203)		
Inflation protection	0.676	0.152	0.656	0.012	0.800	0.328		
Panel C: Summary statistics in 2010								
# Obs.	93	214	64	130	24	51	5	33
%Risky	0.701	0.621	0.728	0.643	0.636	0.611	0.659	0.551
	(0.097)	(0.133)	(0.081)	(0.138)	(0.079)	(0.082)	(0.193)	(0.151)
%Retired	0.389	0.522	0.385	0.554	0.406	0.485	0.360	0.450
	(0.138)	(0.240)	(0.090)	(0.242)	(0.230)	(0.224)	(0.086)	(0.239)
LDR	7.035	5.480	7.617	5.723	6.115	5.914	3.990	3.602
	(1.326)	(1.030)	(0.967)	(0.629)	(0.569)	(0.684)	(1.326)	1.030
Fund size	23.125	7.065	22.715	7.162	11.020	2.156	86.479	14.269
	(44.347)	(13.537)	(36.021)	(11.793)	(21.532)	(2.892)	(127.407)	(23.537)
Inflation protection	0.602	0.224	0.563	0.100	0.708	0.471	0.600	0.333

Table 2: Panel regressions: Percentage allocation to risky assets based on strategic asset allocation

In this table we estimate a panel model and the dependent variable is the percentage allocation 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 and mortgages. As independent variables we include %Retired – percentage of retired members from total pension fund members, Fund size – logarithm of total pension fund assets, Inflation protection – dummy variable taking value one if a fund provides a contractual inflation protection, Public – dummy variable taking value one if a pension fund is public, Public * U.S. – interaction term capturing U.S. public funds, %Retired * Public – interaction term capturing the percentage of retired members among public funds, %Retired * Public * U.S. – interaction term capturing the percentage of retired members among U.S. public funds, Canada and Europe – regional dummy variables (the base result refers to U.S. funds). 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 significance levels with *, ** and ***, which correspond to 0.10, 0.05 and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Percentage allocation to risky assets based on strategic asset allocation							
%Retired	-0.079***	-0.089***	-0.092***	-0.117***	-0.116***	-0.131***	-0.137***	-0.144***
	[0.023]	[0.021]	[0.021]	[0.022]	[0.022]	[0.036]	[0.035]	[0.036]
Fund size	0.005**	0.007***	0.007***	0.008***	0.009***	0.021	0.020	0.019
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.014]	[0.014]	[0.014]
Inflation protection	-0.002	0.010	0.011	0.011	0.011			
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]			
Public		-0.032**	-0.020	-0.066**	-0.030			
		[0.014]	[0.014]	[0.029]	[0.029]			
Public * U.S.			-0.019	-0.016	-0.127***			
			[0.017]	[0.016]	[0.045]			
%Retired * Public				0.117*	0.024		0.089	0.015
				[0.065]	[0.056]		[0.065]	[0.068]
%Retired * Public * U.S.					0.321***			0.253**
					[0.111]			[0.125]
Canada	-0.071***	-0.075***	-0.082***	-0.082***	-0.082***			
	[0.007]	[0.008]	[0.010]	[0.010]	[0.010]			
Europe	-0.128***	-0.138***	-0.142***	-0.145***	-0.144***			
	[0.020]	[0.018]	[0.019]	[0.019]	[0.019]			
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund-fixed effects	No	No	No	No	No	Yes	Yes	Yes
Double clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,806	4,806	4,806	4,806	4,806	4,821	4,821	4,821
R^2	0.195	0.208	0.209	0.215	0.226	0.750	0.751	0.753

Table 3: Panel regressions: Percentage allocation to risky assets based on strategic asset allocation by region

In this table we estimate a panel model and the dependent variable is the percentage allocation to risky assets based on the strategic asset allocation of pension funds. We present the results for U.S. funds in Panel A and Canadian funds in Panel B. As independent variables we include %Retired – percentage of retired members from total pension fund members, Fund size – logarithm of total pension fund assets, Inflation protection – dummy variable taking value one if a fund provides a contractual inflation protection, Public – dummy variable taking value one if a pension fund is public, and %Retired * Public – interaction term capturing the percentage of retired members among public funds. 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 significance levels with *, ** and ***, which correspond to 0.10, 0.05 and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)
Panel A: U.S. pension funds					
%Retired	-0.076**	-0.100***	-0.143***	-0.157***	-0.176***
	[0.032]	[0.028]	[0.027]	[0.046]	[0.047]
Fund size	0.002	0.005*	0.008***	0.027	0.019
	[0.003]	[0.003]	[0.003]	[0.020]	[0.019]
Inflation protection	-0.000	0.023**	0.024**		
	[0.010]	[0.012]	[0.012]		
Public		-0.044**	-0.176***		
		[0.019]	[0.049]		
%Retired * Public			0.374***		0.286**
			[0.110]		[0.114]
Year dummies	Yes	Yes	Yes	Yes	Yes
Fund-fixed effects	No	No	No	Yes	Yes
Double clustering	Yes	Yes	Yes	Yes	Yes
Observations	2,919	2,919	2,919	2,932	2,932
R^2	0.065	0.088	0.120	0.704	0.710
Panel B: Canadian pension funds					
%Retired	-0.091***	-0.090***	-0.083***	-0.078*	-0.078*
	[0.029]	[0.028]	[0.027]	[0.042]	[0.041]
Fund size	0.006	0.008	0.007	0.015	0.015
	[0.005]	[0.005]	[0.005]	[0.026]	[0.025]
Inflation protection	-0.003	-0.001	-0.002		
	[0.009]	[0.010]	[0.010]		
Public		-0.015	-0.007		
		[0.015]	[0.033]		
%Retired * Public			-0.019		0.004
			[0.064]		[0.062]
Year dummies	Yes	Yes	Yes	Yes	Yes
Fund-fixed effects	No	No	No	Yes	Yes
Double clustering	Yes	Yes	Yes	Yes	Yes
Observations	1,619	1,619	1,619	1,621	1,621
R^2	0.149	0.154	0.154	0.701	0.701

Table 4: Percentage allocation to risky assets and controlling for previous year treasury yield

In this table we estimate a panel model and the dependent variable is the percentage allocation 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 and mortgages. Compared to previous results we control for Treasury yield (t-1) – treasury yield in the previous year, Public * Yield (t-1) – interaction term capturing the effect of previous year treasury yield on public funds, and Public * Yield (t-1) * U.S. – interaction terms capturing the effect of previous year treasury yield on U.S. public funds. As independent variables we include Fund size – logarithm of total pension fund assets, Inflation protection – dummy variable taking value one if a fund provides a contractual inflation protection, %Retired – percentage of retired members from total pension fund members, Public – dummy variable taking value one if a pension fund is public, Public * U.S. – interaction term capturing U.S. public funds, Canada and Europe – regional dummy variables (the base result refers to U.S. funds). Where indicated we include year dummies and fund fixed effects. We double cluster the standard errors by pension fund and by year. We report standard errors in brackets and significance levels with *, ** and ***, which correspond to 0.10, 0.05 and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Percentage allocation to risky assets based on strategic asset allocation							
Treasury yield(t-1)	-0.012***	-0.002	-0.002	-0.005	-0.006	-0.001	0.000	-0.004
	[0.004]	[0.004]	[0.004]	[0.004]	[0.005]	[0.005]	[0.005]	[0.005]
Public * Yield(t-1)		-0.034***	-0.026***	-0.024***		-0.017***	-0.010*	-0.009
		[0.005]	[0.005]	[0.005]		[0.005]	[0.006]	[0.005]
Public * Yield(t-1) * U.S.			-0.013*	-0.013*			-0.018**	-0.018**
			[0.008]	[0.008]			[0.008]	[0.008]
Fund size	0.008***	0.007***	0.007***	0.008***	0.040***	0.039***	0.039***	0.041***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.012]	[0.012]	[0.012]	[0.013]
Inflation protection	0.013*	0.015**	0.015**	0.013*				
	[0.007]	[0.007]	[0.008]	[0.007]				
%Retired				-0.087***				-0.107***
				[0.021]				[0.036]
Public	-0.024*	0.164***	0.123***	0.113***				
	[0.015]	[0.027]	[0.030]	[0.028]				
Public * U.S.		-0.017	0.053	0.047				
		[0.018]	[0.041]	[0.041]				
Canada	-0.069***	-0.077***	-0.077***	-0.078***				
	[0.008]	[0.010]	[0.010]	[0.009]				
Europe	-0.133***	-0.133***	-0.132***	-0.139***				
	[0.018]	[0.019]	[0.018]	[0.019]				
Year dummies	No	No	No	No	No	No	No	No
Fund-fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
Double clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,806	4,806	4,806	4,806	4,821	4,821	4,821	4,821
R^2	0.166	0.196	0.198	0.216	0.728	0.737	0.741	0.745

Table 5: U.S. public pension funds: changes in allocation to risky assets and changes in self-reported funding ratio

In this table we estimate a panel model and the dependent variable is the change in percentage allocation to risky assets based on the strategic asset allocation of pension funds. We focus on the effect of Cumulative ΔSRFR – cumulative change in the self-reported funding ratio of U.S. public pension funds over the last years. The cumulative change includes the change in self-reported funding ratio from year *t-1* to year *t* ($\Delta SRFR_t$) and the change from year *t-2* to year *t-1* ($\Delta SRFR_{t-1}$). We also control for the change in percentage retired members (Δ%Retired) and the change in fund size (ΔFund size) between year *t* and year *t-1*. In models (1) – (3) we use all observations, whereas in models (4) – (6) we focus on the subperiod 2006–2010. In all models, 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 significance levels with *, ** and ***, which correspond to 0.10, 0.05 and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variables: changes in percentage allocation to risky assets					
	All observations			2006-2010 subperiod		
Cumulative ΔSRFR	-0.040***	-0.042**		-0.059**	-0.084***	
	[0.015]	[0.020]		[0.026]	[0.025]	
$\Delta SRFR_t$			-0.060**			-0.082**
			[0.030]			[0.034]
$\Delta SRFR_{t-1}$			-0.024			-0.086***
			[0.031]			[0.028]
Δ%Retired		-0.013	-0.009		0.143	0.143
		[0.125]	[0.124]		[0.132]	[0.131]
ΔFund size		0.029	0.029		0.113***	0.113***
		[0.046]	[0.045]		[0.040]	[0.041]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Fund fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Double clustering	Yes	Yes	Yes	Yes	Yes	Yes
Observations	527	508	508	260	252	252
R^2	0.206	0.207	0.208	0.150	0.199	0.199

Table 6: The decision of U.S. public pension funds to use smoothing period in the asset valuation

We present the results of use logit regressions explaining whether a U.S. public pension funds smooth the valuation of their assets. As independent variables on pension fund risk-taking we include %Risky – percentage strategic allocation to risky assets or decompose it to %Equity – percentage allocation to equity, %Alternatives – percentage allocation alternative assets and %RiskyFI – percentage allocation to risky fixed income assets. We also control for Δ%lRisky$_{t-1}$ – lagged change in the percentage allocation to risky assets, %Retired – percentage of retired members from total pension fund members, Fund size – logarithm of total pension fund assets, Inflation protection – dummy variable taking value one if a fund provides a contractual inflation protection. As independent variables on previous year returns we include NTR$_{t-1}$ – net return of pension funds in the previous year, MKT$_{t-1}$ – the equity market return in *t-1*, and NTR-BM$_{t-1}$ – net benchmark-adjusted return of pension funds in the previous year. We present the marginal effects (elasticities) at the means of the independent variables. The marginal effects for the dummy variables are estimated for discrete changes from 0 to 1. We also include year dummies and independently double cluster the standard errors by pension fund and by year. We report standard errors in brackets and significance levels with *, ** and ***, which correspond to 0.10, 0.05 and 0.01, respectively.

	Dependent variable: Logit regressions - probability to use smoothing in asset valuation					
	(1)	(2)	(3)	(4)	(5)	(6)
%Risky	1.349*	1.351*	1.392*	1.323*	1.371*	
	[0.714]	[0.799]	[0.812]	[0.802]	[0.820]	
%Equity						1.609*
						[0.893]
%Alternatives						1.009
						[0.936]
%RiskyFI						2.374
						[2.119]
Δ%Risky$_{t-1}$	-0.488	-0.472	-0.217	-0.484	-0.175	-0.240
	[0.565]	[0.571]	[0.578]	[0.577]	[0.611]	[0.633]
%Retired		-0.245	-0.081	-0.263	-0.207	-0.149
		[1.096]	[1.055]	[1.091]	[1.064]	[1.157]
Fund size	-0.084	-0.086	-0.099	-0.086	-0.098	-0.094
	[0.065]	[0.067]	[0.062]	[0.067]	[0.061]	[0.062]
Inflation protection		0.099	0.091	0.099	0.090	0.111
		[0.114]	[0.115]	[0.114]	[0.115]	[0.117]
NTR$_{t-1}$			0.612			
			[0.980]			
MKT$_{t-1}$				0.767		
				[0.671]		
NTR-BM$_{t-1}$					-1.972*	-2.121*
					[1.156]	[1.167]
Year dummies	Yes	Yes	No	No	No	No
Fund-fixed effects	No	No	No	No	No	No
Double clustering	Yes	Yes	Yes	Yes	Yes	Yes
Observations	374	372	370	372	370	370
Pseudo R^2	0.066	0.077	0.090	0.078	0.096	0.104

Table 7: Regression results: Liability discount rates

In this table we estimate a panel model and the dependent variable is the liability discount rate used by the pension funds. As independent variables we include %Risky – percentage allocation to risky assets based on strategic asset allocation policy, %Retired – percentage of retired members from total pension fund members, Fund size – logarithm of total pension fund assets, Inflation protection – dummy variable taking value one if a fund provides a contractual inflation protection, Public – dummy variable taking value one if a pension fund is public, Public * U.S. – interaction term capturing U.S. public funds, %Risky * Public – interaction term capturing the percentage allocation to risky assets of public funds, %Risky * Public * U.S. – interaction term capturing the allocation to risky assets of U.S. public funds, %Retired * Public – interaction term capturing the percentage of retired members among public funds, %Retired * Public * U.S. – interaction term capturing the percentage of retired members among U.S. public funds, Canada and Europe – regional dummy variables (the base result refers to U.S. funds). 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 significance levels with *, ** and ***, which correspond to 0.10, 0.05 and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Dependent variable: Liability discount rate used by pension funds											
%Risky	0.604**	0.784***	0.846***	0.054	0.040	0.800***	0.687***	0.960***	0.727*	0.431	0.890***	0.749**
	[0.250]	[0.246]	[0.236]	[0.259]	[0.261]	[0.229]	[0.227]	[0.336]	[0.392]	[0.388]	[0.332]	[0.312]
%Retired	-0.361**	-0.234	-0.147	-0.185	-0.215*	-0.295**	-0.299**	-0.709***	-0.693***	-0.676***	-0.806***	-0.931***
	[0.162]	[0.147]	[0.127]	[0.120]	[0.124]	[0.140]	[0.139]	[0.238]	[0.238]	[0.242]	[0.244]	[0.255]
Fund size	0.067***	0.038**	0.039**	0.034**	0.037**	0.044***	0.049***	0.077	0.069	0.097	0.056	0.046
	[0.017]	[0.017]	[0.016]	[0.016]	[0.016]	[0.016]	[0.017]	[0.120]	[0.120]	[0.115]	[0.120]	[0.123]
Inflation protection	0.160*	0.037	-0.001	-0.022	-0.013	0.003	-0.002					
	[0.092]	[0.077]	[0.072]	[0.070]	[0.069]	[0.073]	[0.073]					
Public		0.348***	-0.059	-1.345***	-0.481	-0.317**	-0.066					
		[0.123]	[0.100]	[0.304]	[0.561]	[0.159]	[0.170]					
Public * U.S.			0.644***	0.473***	-0.798	0.663***	-0.168					
			[0.181]	[0.178]	[0.675]	[0.181]	[0.352]					
%Risky * Public				2.154***	0.709				0.546	-0.056		
				[0.495]	[0.922]				[0.348]	[0.389]		
%Risky * Public * U.S.					2.033*					1.749***		
					[1.049]					[0.578]		
%Retired * Public						0.655*	-0.008				1.218***	0.083
						[0.366]	[0.317]				[0.459]	[0.392]
%Retired * Public * U.S.							2.393***					3.989***
							[0.745]					[1.409]
Canada	-0.586***	-0.535***	-0.309***	-0.380***	-0.381***	-0.315***	-0.318***					
	[0.095]	[0.094]	[0.094]	[0.095]	[0.095]	[0.093]	[0.093]					
Europe	-3.316***	-3.174***	-3.027***	-3.086***	-3.101***	-3.044***	-3.060***					
	[0.174]	[0.194]	[0.213]	[0.210]	[0.212]	[0.214]	[0.215]					
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund-fixed effects	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Double clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,653	4,653	4,653	4,653	4,653	4,653	4,653	4,666	4,666	4,666	4,666	4,666
R^2	0.530	0.542	0.553	0.560	0.562	0.555	0.559	0.773	0.774	0.775	0.775	0.779

Table 8: Regression results: Liability discount rates and treasury yields

In this table we estimate a panel model and the dependent variable is the liability discount rate used by the pension funds. We control for Treasury yield – 10 year treasury yield, Public * Yield – interaction term capturing the effect of treasury yield on public funds, and Public * Yield * U.S. – interaction terms capturing the effect of treasury yield on U.S. public funds. As independent variables we also include %Risky – percentage strategic allocation to risky assets, %Retired – percentage of retired members from total pension fund members, Fund size – logarithm of total pension fund assets, Inflation protection – dummy variable taking value one if a fund provides a contractual inflation protection, Public – dummy variable taking value one if a pension fund is public, Public * U.S. – interaction term capturing U.S. public funds, %Risky * Public – interaction term capturing the percentage allocation to risky assets of public funds, %Risky * Public * U.S. – interaction term capturing the allocation to risky assets of U.S. public funds, %Retired * Public – interaction term capturing the percentage of retired members among public funds, %Retired * Public * U.S. – interaction term capturing the percentage of retired members among U.S. public funds, Canada and Europe – regional dummy variables (the base result refers to U.S. funds). 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 significance levels with *, ** and ***, which correspond to 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							
Treasury yield	0.389***	0.392***	0.390***	0.462***	0.462***	0.249***	0.278***	0.297***
	[0.032]	[0.031]	[0.030]	[0.042]	[0.042]	[0.035]	[0.044]	[0.048]
Public * Yield				-0.257***	-0.077		-0.089*	0.015
				[0.051]	[0.055]		[0.047]	[0.041]
Public * Yield * U.S.					-0.298***			-0.251***
					[0.057]			[0.070]
%Risky	0.559**	0.727***	0.773***	0.497**	0.457*	0.855**	0.686*	0.522
	[0.273]	[0.265]	[0.255]	[0.230]	[0.234]	[0.380]	[0.353]	[0.355]
%Retired	-0.472***	-0.339**	-0.257**	-0.231*	-0.243*	-1.180***	-1.119***	-1.082***
	[0.166]	[0.148]	[0.129]	[0.125]	[0.126]	[0.242]	[0.245]	[0.237]
Fund size	0.058***	0.028	0.028*	0.026	0.025	-0.314**	-0.316***	-0.294**
	[0.016]	[0.017]	[0.016]	[0.016]	[0.016]	[0.122]	[0.121]	[0.118]
Inflation protection	0.151*	0.025	-0.010	0.007	0.007			
	[0.092]	[0.077]	[0.072]	[0.070]	[0.069]			
Public		0.358***	-0.032	1.290***	0.379			
		[0.123]	[0.103]	[0.254]	[0.277]			
Public * U.S.			0.613***	0.555***	2.052***			
			[0.188]	[0.195]	[0.286]			
Canada	-0.696***	-0.648***	-0.436***	-0.496***	-0.504***			
	[0.089]	[0.090]	[0.107]	[0.106]	[0.107]			
Europe	-3.363***	-3.218***	-3.080***	-3.094***	-3.077***			
	[0.153]	[0.175]	[0.195]	[0.191]	[0.189]			
Year dummies	No	No	No	No	No	No	No	No
Fund-fixed effects	No	No	No	No	No	Yes	Yes	Yes
Double clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,653	4,653	4,653	4,653	4,653	4,666	4,666	4,666
R^2	0.508	0.521	0.531	0.544	0.549	0.761	0.762	0.767

Table 9: Panel regressions: Liability discount rates by region

In this table we estimate a panel model and the dependent variable is the liability discount rate used by pension funds. We present the results separately for U.S. funds in columns (1) to (4) and Canadian funds in columns (5) to (8). As independent variables we include Treasury yield – 10 year treasury yield, Public * Yield – interaction term capturing the effect of treasury yield on public funds, %Risky – percentage strategic allocation to risky assets, %Retired – percentage of retired members from total pension fund members, Fund size – logarithm of total pension fund assets, Inflation protection – dummy variable taking value one if a fund provides a contractual inflation protection, Public – dummy variable taking value one if a pension fund is public, %Risky * Public – interaction term capturing the percentage allocation to risky assets of public funds and %Retired * Public – interaction term capturing the percentage of retired members among public funds. 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 significance levels with *, ** and ***, which correspond to 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							
	U.S.	U.S.	U.S.	U.S.	Canada	Canada	Canada	Canada
Treasury yield	0.580***	0.575***	0.410***	0.394***	0.358***	0.369***	0.215***	0.214***
	[0.055]	[0.054]	[0.072]	[0.071]	[0.040]	[0.041]	[0.051]	[0.052]
Public * Yield	-0.467***	-0.455***	-0.329***	-0.308***	0.042	0.001	0.034	0.037
	[0.061]	[0.060]	[0.084]	[0.077]	[0.048]	[0.047]	[0.046]	[0.048]
%Risky	0.215	0.402*	-0.073	0.362	-0.196	0.220	-0.097	-0.088
	[0.276]	[0.222]	[0.525]	[0.394]	[0.457]	[0.558]	[0.579]	[0.435]
%Retired	-0.487***	-0.636***	-1.150***	-1.450***	-0.105	0.077	-0.617*	-0.615*
	[0.154]	[0.144]	[0.324]	[0.340]	[0.218]	[0.260]	[0.317]	[0.319]
Fund size	0.053***	0.065***	-0.301**	-0.342**	0.007	0.012	-0.451**	-0.450**
	[0.017]	[0.018]	[0.152]	[0.149]	[0.036]	[0.036]	[0.206]	[0.204]
Inflation protection	0.077	0.087			-0.104	-0.095		
	[0.095]	[0.095]			[0.099]	[0.103]		
Public	2.251***	2.229***			-0.934	0.192		
	[0.488]	[0.439]			[0.770]	[0.322]		
%Risky * Public	0.818*		1.444		1.193		0.005	
	[0.486]		[0.935]		[1.130]		[0.506]	
%Retired * Public		1.474**		3.724***		-0.511		-0.049
		[0.579]		[1.122]		[0.457]		[0.470]
Year dummies	No	No	No	No	No	No	No	No
Fund-fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Double clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,854	2,854	2,865	2,865	1,575	1,575	1,577	1,577
R^2	0.339	0.343	0.642	0.650	0.305	0.305	0.667	0.667

Table 10: Panel regressions: U.S. public pension funds – liability discount rates and funding ratios

In this table we estimate a panel model and the dependent variable is the liability discount rate used by U.S. public pension funds. As independent variables we include %Risky – percentage allocation to risky assets based on strategic asset allocation policy, %Retired – percentage of retired members from total pension fund members, Fund size – logarithm of total pension fund assets, Inflation protection – dummy variable taking value one if a fund provides a contractual inflation protection, SR Funding ratio - self-reported funding ratio of U.S. public funds and Smoothing – dummy variable taking value one if pension funds smooth the asset valuation over time. In models (1) – (6) we use all observations, whereas in models (7) – (8) we focus on the subperiod 2006–2010. In all models we include year dummies. We independently double cluster the robust standard errors by pension fund and by year. We report standard errors in brackets and significance levels with *, ** and ***, which correspond to 0.10, 0.05 and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Liability discount rate used by U.S. public funds						
%Risky	0.993**		0.893*	1.830***	1.503*	1.608***	1.476**
	[0.440]		[0.471]	[0.668]	[0.903]	[0.544]	[0.707]
%Retired		0.981**	0.849*	1.340	2.023	1.174	2.687
		[0.494]	[0.498]	[0.953]	[1.620]	[1.059]	[1.749]
Fund size	0.052**	0.068**	0.062**	0.081*	0.065	0.108	0.080
	[0.026]	[0.027]	[0.027]	[0.043]	[0.057]	[0.067]	[0.052]
Inflation protection	0.133	0.162	0.140	0.233	0.141	0.309*	0.043
	[0.126]	[0.127]	[0.128]	[0.144]	[0.123]	[0.162]	[0.169]
SR Funding ratio				-1.139**	-1.392*	-1.951**	-2.162**
				[0.554]	[0.797]	[0.753]	[0.910]
Smoothing					-0.282*		-0.154
					[0.168]		[0.236]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund fixed-effects	No	No	No	No	No	No	No
Double clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,146	1,127	1,127	742	413	316	198
R-squared	0.041	0.036	0.044	0.081	0.104	0.132	0.142

Table 11: Logit regressions: Contractual inflation protection

In this table we estimate a logit model whether a pension fund provides a contractual inflation protection. In columns (1), (2), (3) and (4) the dependent variable is defined across all funds. Columns (5), (6) and (7) focus only on the U.S. funds, and columns (8), (9) and (10) present the results only for Canadian funds. As independent variables we include %Retired – percentage of retired members from total pension fund members, Fund size - logarithm of total pension fund assets, Public – dummy variable taking value one if a it is a public pension fund, Public * U.S. – interaction term capturing public U.S. funds, %Retired * Public – interaction term capturing the percentage of retired members among public funds, %Retired * Public * U.S. – interaction term capturing the percentage of retired members among U.S. public funds, Canada and Europe – regional dummy variables (the base result refers to U.S. funds).. We present the marginal effects (elasticities) at the means of the independent variables. The marginal effects for the dummy variables are estimated for discrete changes from 0 to 1. We also include year dummies and independently double cluster the robust standard errors by pension fund and by year.

	(1) All funds	(2) All funds	(3) All funds	(4) All funds	(5) U.S.	(6) U.S.	(7) U.S.	(8) Canada	(9) Canada	(10) Canada
%Retired	-0.409***	-0.287**	-0.213*	-0.189	-0.554***	-0.216*	-0.218*	-0.263	-0.274	-0.204
	[0.102]	[0.134]	[0.119]	[0.129]	[0.115]	[0.115]	[0.134]	[0.191]	[0.202]	[0.238]
Fund size	0.056***	0.018	0.016	0.016	0.028*	-0.020	-0.020	0.132***	0.120***	0.119***
	[0.015]	[0.016]	[0.015]	[0.015]	[0.018]	[0.015]	[0.015]	[0.031]	[0.032]	[0.032]
Public		0.417***	0.198***	0.244		0.464***	0.461***		0.187**	0.256
		[0.054]	[0.077]	[0.165]		[0.050]	[0.125]		[0.095]	[0.176]
Public * U.S.			0.378***	0.326						
			[0.103]	[0.205]						
%Retired * Public				-0.105			0.006			-0.190
				[0.309]			[0.229]			[0.398]
%Ret. * Public * U.S.				0.118						
				[0.389]						
Canada	0.353***	0.409***	0.541***	0.541***						
	[0.053]	[0.058]	[0.061]	[0.061]						
Europe	-0.104	0.063	0.230**	0.232**						
	[0.071]	[0.105]	[0.113]	[0.114]						
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Double clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4806	4806	4806	4806	2918	2918	2918	1618	1618	1618
Pseudo R^2	0.097	0.199	0.218	0.218	0.021	0.272	0.272	0.088	0.105	0.106

Table 12: Pension fund net benchmark-adjusted performance

We estimate a panel model and the dependent variable is pension fund net benchmark-adjusted performance. As independent variables we include %Risky – percentage allocation to risky assets based on strategic asset allocation policy, Δ%Risky$_{t-1}$ – lagged change in the percentage allocation to risky assets, %Retired – percentage of retired members from total pension fund members, Fund size – logarithm of total pension fund assets, Inflation protection – dummy variable taking value one if a fund provides a contractual inflation protection, Public – dummy variable taking value one if a pension fund is public, Public * U.S. – interaction term capturing U.S. public funds, %Risky * Public – interaction term capturing the percentage allocation to risky assets of public funds, %Risky * Public * U.S. – interaction term capturing the allocation to risky assets of U.S. public funds, %Retired * Public – interaction term capturing the percentage of retired members among public funds, %Retired * Public * U.S. – interaction term capturing the percentage of retired members among U.S. public funds, and NTR-BM$_{t-1}$ – net benchmark-adjusted return of pension funds in the previous year. In all models we include year dummies and region fixed effects (Europe, Canada and U.S.). We independently double cluster the robust standard errors by pension fund and by year. We report standard errors in brackets and significance levels with *, ** and ***, which correspond to 0.10, 0.05 and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Dependent variable: Net benchmark-adjusted returns										
%Risky	0.198	0.073	0.023	0.351	0.360	0.067	0.104	0.016	-0.171	-0.076	0.010
	[0.865]	[0.817]	[0.800]	[1.126]	[1.128]	[0.797]	[0.798]	[0.892]	[0.839]	[1.101]	[0.792]
Δ%Risky$_{t-1}$								-1.994**	-1.743*	-1.788*	-1.755**
								[0.934]	[0.907]	[0.963]	[0.889]
%Retired	0.178	0.094	0.010	0.024	0.041	0.165	0.166	0.176	-0.010	0.022	0.362
	[0.259]	[0.268]	[0.278]	[0.272]	[0.270]	[0.290]	[0.290]	[0.235]	[0.222]	[0.208]	[0.296]
Fund size	0.025	0.044	0.044	0.046	0.044	0.038	0.037	0.075	0.088*	0.085*	0.073
	[0.053]	[0.049]	[0.049]	[0.050]	[0.050]	[0.049]	[0.050]	[0.051]	[0.048]	[0.050]	[0.049]
Inflation protection	-0.039	0.047	0.082	0.089	0.084	0.078	0.079	-0.125	-0.026	-0.030	-0.036
	[0.123]	[0.128]	[0.125]	[0.130]	[0.129]	[0.125]	[0.125]	[0.159]	[0.139]	[0.143]	[0.140]
NTR-BM$_{t-1}$								-0.003	-0.006	-0.007	-0.008
								[0.106]	[0.106]	[0.106]	[0.106]
Public		-0.241*	0.134	0.652	0.163	0.403*	0.312		0.247	-0.312	0.670**
		[0.135]	[0.171]	[0.600]	[0.445]	[0.232]	[0.266]		[0.203]	[0.680]	[0.337]
Public * U.S.			-0.593***	-0.521***	0.184	-0.613***	-0.322		-0.672***	0.357	-0.211
			[0.170]	[0.191]	[0.406]	[0.169]	[0.271]		[0.204]	[0.676]	[0.339]
%Risky * Public				-0.872	-0.048					0.923	
				[1.105]	[0.803]					[1.019]	
%Risky * Public * U.S.					-1.135***					-1.597*	
					[0.382]					[0.841]	
%Retired * Public						-0.682***	-0.445				-1.061**
						[0.218]	[0.336]				[0.425]
%Retired * Public * U.S.							-0.832**				-1.433**
							[0.422]				[0.676]
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Double clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,771	4,771	4,771	4,771	4,771	4,771	4,771	3,221	3,221	3,221	3,221
R^2	0.122	0.123	0.125	0.125	0.125	0.125	0.125	0.135	0.139	0.139	0.140

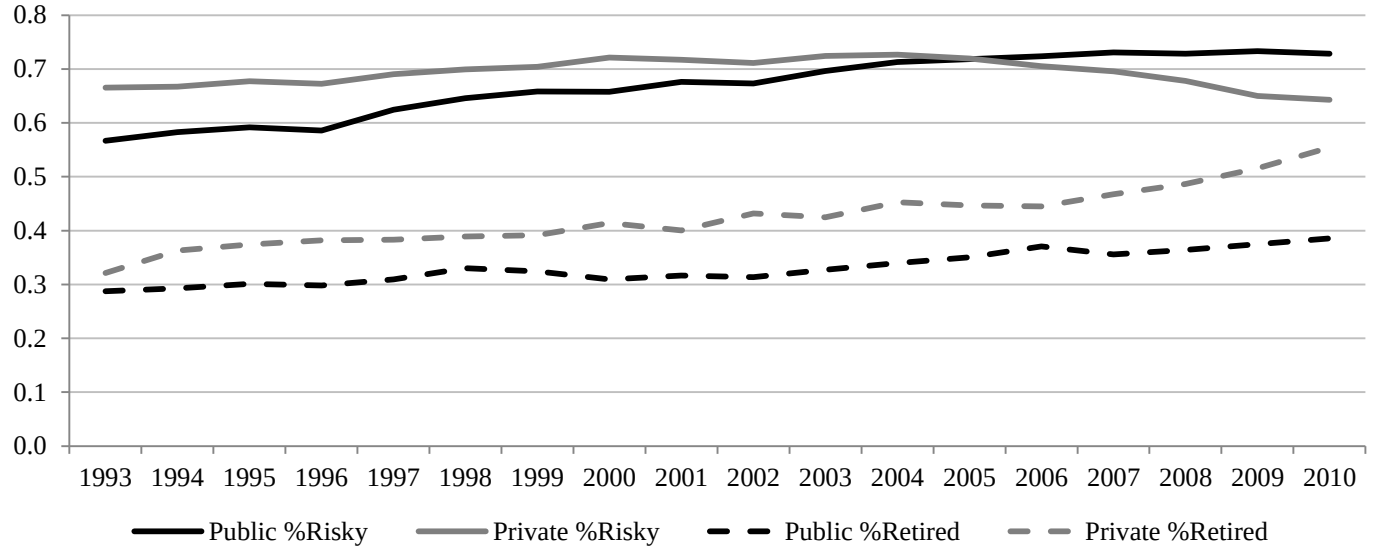
Table 13: U.S. public pension fund net benchmark-adjusted performance

In this table we estimate a panel model and the dependent variable is the net benchmark-adjusted performance of U.S. public pension funds. In models (1) and (2) we use the net benchmark-adjusted returns as they are reported in the database. In models (3) and (4) in the first stage we risk-adjust the net benchmark-adjusted returns using a five-factor model that includes the equity market return, SMB, HML, momentum factor and Pastor and Stambaugh () traded liquidity factor. In the second step we augment the alphas retrieved from the first step with the error terms of the first step and estimate panel regressions. In the panel regressions we include the following independent variables: %Risky – percentage allocation to risky assets based on strategic asset allocation policy, Δ%Risky$_{t-1}$ – lagged change in the percentage allocation to risky assets, %Retired – percentage of retired members from total pension fund members, Fund size – logarithm of total pension fund assets, Inflation protection – dummy variable taking value one if a fund provides a contractual inflation protection, Public – dummy variable taking value one if a pension fund is public, and NTR-BM$_{t-1}$ – net benchmark-adjusted return of pension funds in the previous year. 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 significance levels with *, ** and ***, which correspond to 0.10, 0.05 and 0.01, respectively.

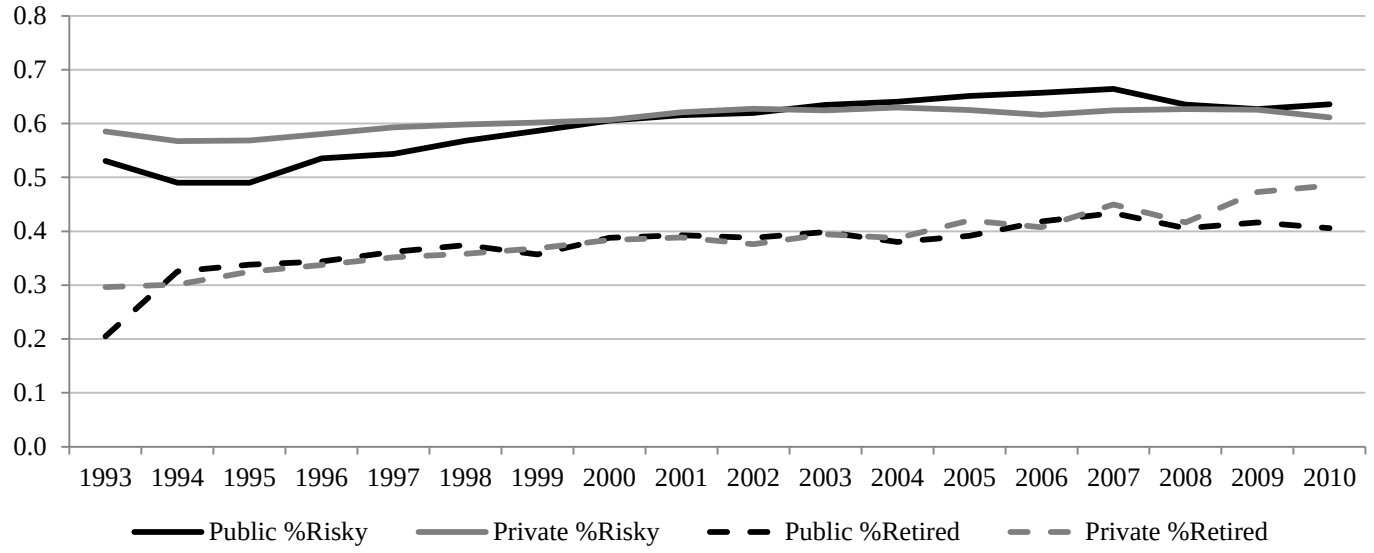
	(1)	(2)	(3)	(4)
Dependent variable:	*Net benchmark-adjusted returns*		*Risk-adjusted net benchmark-adjusted returns*	
%Risky	-0.360	1.266	1.144	1.256
	[0.997]	[2.135]	[1.142]	[0.890]
Δ%Risky$_{t-1}$	-1.194	-1.565	-4.981**	-1.792*
	[1.356]	[1.664]	[2.132]	[0.924]
%Retired	-2.747**	-4.148*	-4.830*	-3.821**
	[1.192]	[2.350]	[2.523]	[1.905]
Fund size	0.060	1.689	-0.256	1.266
	[0.105]	[2.013]	[0.230]	[0.792]
Inflation protection	-0.116		-0.242	
	[0.305]		[0.503]	
NTR-BM$_{t-1}$	-0.130	-0.203	0.129*	0.005
	[0.150]	[0.143]	[0.076]	[0.033]
Year dummies	Yes	Yes	Yes	Yes
Fund dummies	No	Yes	No	Yes
Double clustering	Yes	Yes	Yes	Yes
Observations	843	843	805	805
R-squared	0.127	0.225	0.099	0.732

Figure 1: Percentage retired members and percentage allocation to risky assets by region and plan type

Panel A: U.S. funds - Percentage allocation to risky assets and percentage retired members



Panel B: Canadian funds - Percentage allocation to risky assets and percentage retired members



Panel C: European funds - Percentage allocation to risky assets and percentage retired members

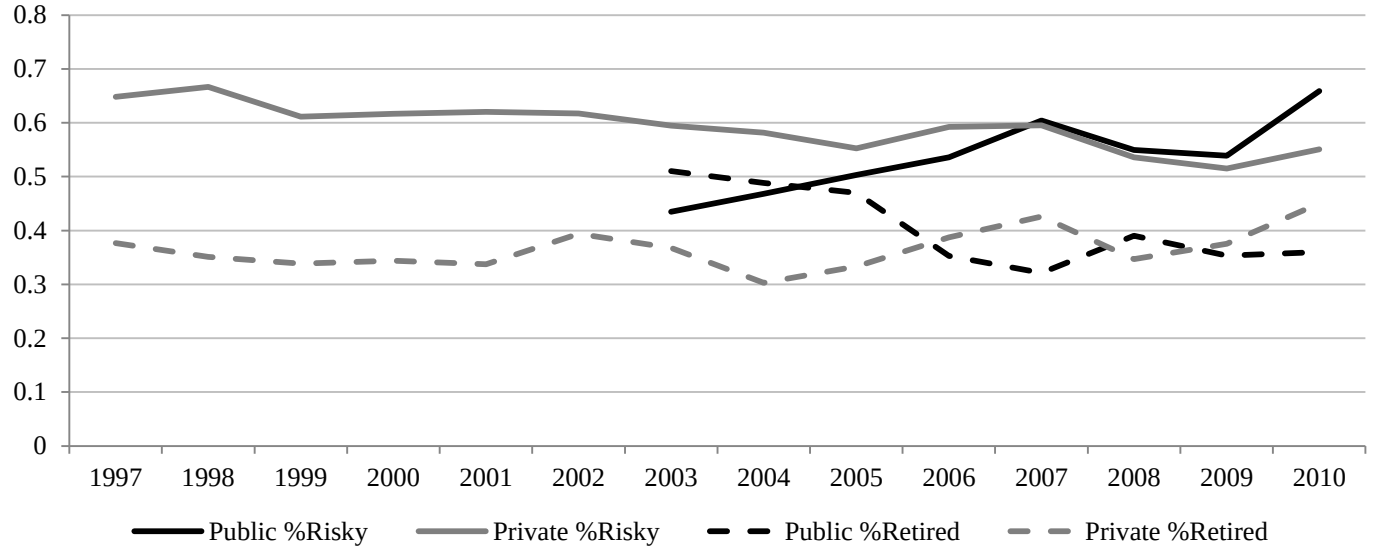
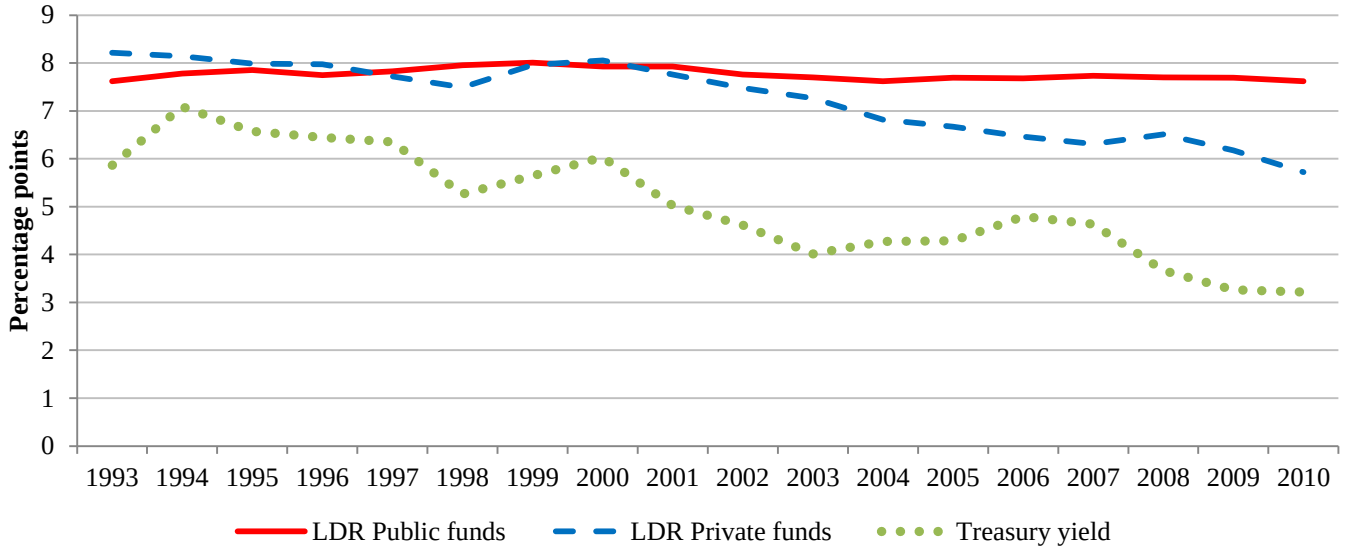
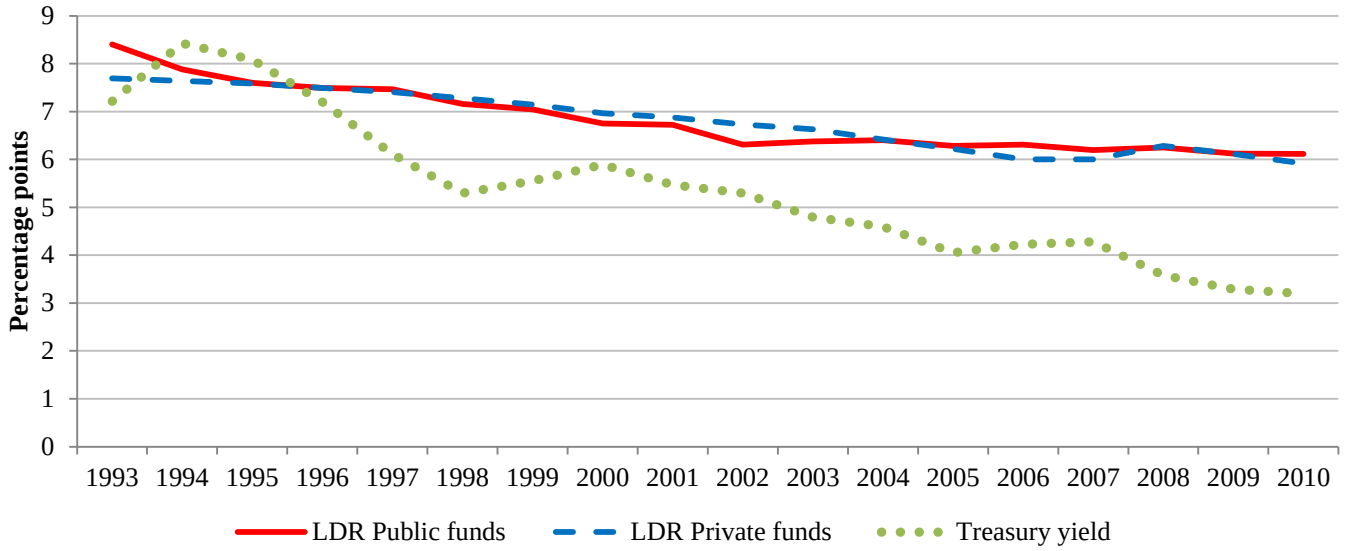


Figure 2: Liability discount rates (LDR) and treasury yields

Panel A: U.S. funds - Liability discount rates (LDR) and 10-year treasury yield



Panel B : Canadian funds - Liability discount rates (LDR) and 10-year treasury yield



Panel C: European funds - Liability discount rates (LDR) and 10-year treasury yield

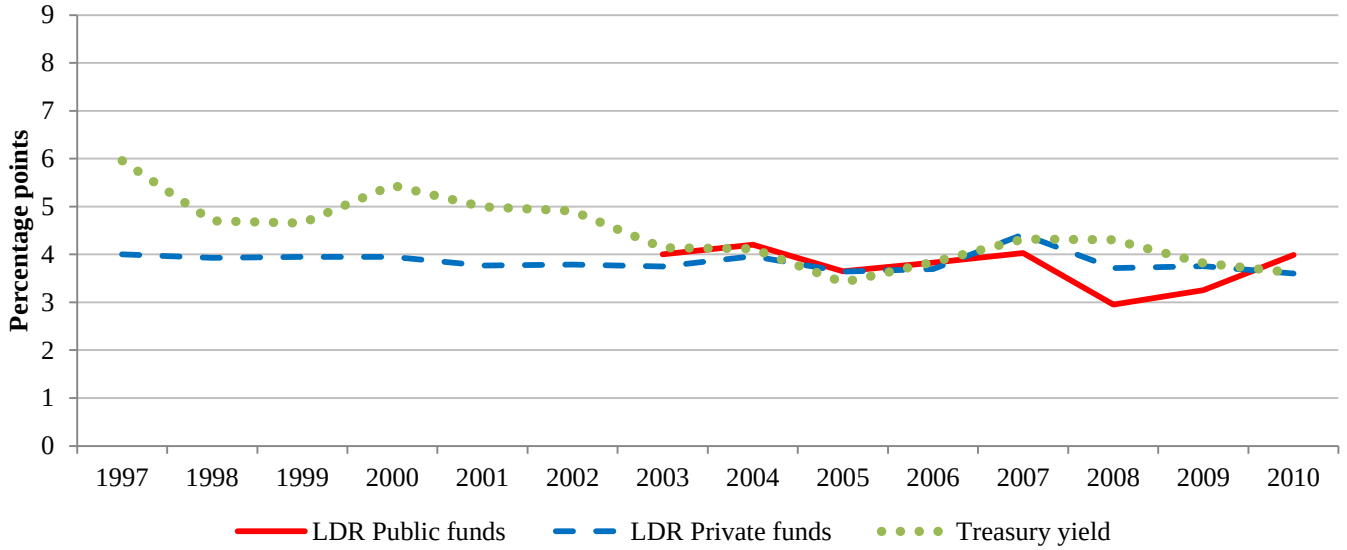


Figure 3: U.S. public funds: self-reported funding ratio (SRFR) and percentage of funds smoothing the asset valuation