Do pension plans manipulate pension liabilities?*

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Abstract

We employ the fundamental details of U.S. pension funding law to test whether corporate defined benefit (DB) pension plans manipulate reported pension liabilities. Using a large sample of 11,963 plans, we find that reported pension liabilities are understated by approximately 10 percent. Most of the bias is driven by higher assumed discount rates, whereas a small fraction relates to the use of outdated longevity assumptions. The bias is particularly strong for underfunded plans. These findings are relevant for current policy discussions, as U.S. lawmakers have recently given more freedom to DB pension plan sponsors to reduce their reported pension liabilities.

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1 Introduction

In 2012, the U.S. government signed into law the Moving Ahead for Progress in the 21st Century Act (MAP-21). This bill is principally aimed at enhancing funding for certain infrastructure projects, but it also contains provisions on corporate defined benefit (DB) pension plans. Specifically, it allows DB pension plan sponsors to use a higher discount rate when computing the present value of pension liabilities, thereby directly increasing the level of plan funding while decreasing the amount of mandatory contributions to the pension plan.

Giving more freedom to plan sponsors to choose actuarial assumptions involves a difficult trade-off. While a temporary funding relief for underfunded pension plans may help restore the long-term viability of plan sponsors, it may go against the interests of their employees and retirees. By reducing pension contributions, both credit risk and longevity risk (the risk of retirees outliving their financial resources) is shifted from shareholders to pension plan participants. For well funded and financially healthy pension plans, this risk may be negligible. However, it may become more relevant if risky pension plans are more likely to opt for this temporary funding relief.

The objective of this paper is to investigate whether underfunded pension plans are in general more likely to stretch actuarial assumptions in order to reduce the reported value of pension liabilities. To answer this question, we focus on a large sample of pension plans provided by the U.S. Department of Labor (DOL), specifically on the Form 5500 data, which contain detailed information on various actuarial assumptions, including the mortality tables or discount rates used in the computation of plan pension liabilities.

Our main analysis is based on a sample of 11,963 U.S. corporate DB pension plans over the period from 1999 to 2007. The sample period is driven by a historical experiment which followed from a detailed study of U.S. pension funding law. Up until 2008, the Internal Revenue Service (IRS) required plan sponsors to employ two liability concepts: a current and an accrued liability measure. The choice of discount rates and mortality tables used for the current liability calculation were imposed by legislation, whereas for accrued liabilities plan sponsors were given more discretion. Both liability measures co-existed over the sample period and they affected pension contributions differently: accrued liabilities were used to compute the normal level of contributions to the pension fund whereas the current liability measure was the basis for additional top-up contributions for underfunded plans.

We find that, on average, accrued pension liabilities would have to be increased by 10 percent in order to keep up with the tightly regulated current liability measure. This downward bias is to a large degree driven by the choice of significantly higher discount rates. On average, corporate DB pension plans employed discount rates for the accrued pension liability concept that exceeded the regulated measure by approximately 170 basis points. In addition, we also find that a small subset of pension plans made substantially lower and outdated life expectancy assumptions.

Most importantly, our analysis reveals that the downward bias of pension liabilities is strongest for underfunded pension plans as they employ substantially higher discount rate assumptions. This is interesting as, from a legal perspective, the discount rate used to estimate the accrued pension liability should not be related to the funding status of the pension plan. The results suggest manipulative behavior of pension plans – by relying on higher discount rates, sponsors of underfunded plans lower normal contributions which could help offset some of the impact of additional required contributions.

We then test whether credit risk of the plan sponsor helps to explain this finding. While actuarial assumptions should not reflect credit risk characteristics of the plan sponsor, such a relation would still still be consistent with simple economic arguments. After all, pension promises of underfunded pension plans may simply be more risky and it therefore could be rational (though unlawful) to in turn increase discount rates. However, we show that this explanation is incomplete. When merging our sample of pension plans with Compustat we find that the relation exists even among plan sponsors of small plans, plans with low consolidated leverage ratios or plan's with low measures of credit risk.

While the Pension Protection Act (PPA) of 2006 eliminated the co-existence of the two liability measures, our results continue to be highly relevant. To illustrate, we relate our findings to the recently introduced MAP-21 bill, which (loosely speaking) gave DB pension plans the option of using higher discount rates when computing pension liabilities. Using another sample of 5,452 corporate DB pension plans that filed with the IRS in 2012, we find that underfunded plans were substantially more likely to be early adopters of the new legislation. The benefit of the adoption followed immediately: mandatory pension contributions decreased by 37 percent for pension plans that switched to the new rule, whereas they increased by 33 percent for those plans that postponed adoption of MAP-21 until 2013.

Why do these findings matter? In a frictionless world, lower reported values of pension liabilities would merely impact the timing of pension contributions but pension claims and other corporate securities would be correctly priced. Put differently, financing decisions are irrelevant (Modigliani and Miller, 1958) and wages would be set such that workers only cared about total compensation and would be thus indifferent between (unreported) market values of retirement schemes offered by DB and defined contribution plans (Rauh, Stefanescu, and Zeldes, 2013). In reality, various frictions including taxes, bankruptcy costs, external financing fees and agency costs affect investment, capital structure choice, compensation policy and ultimately firm value (Jensen and Meckling, 1976; Myers and Majluf, 1984; Fazzari, Hubbard, and Petersen, 1988; Fischer, Heinkel, and Zechner, 1989; Erickson and Whited, 2000; Hennessy and Whited, 2005).

The findings in this paper thus contribute to a broad literature on how pension fund management is impacted by various real-life frictions. For instance, Bergstresser, Desai, and Rauh (2006) provide evidence that corporations offering private DB pension funds manipulate earnings by opportunistically changing future return assumptions of the underlying pension plans. The reason is that higher return on asset assumptions reduce pension expenses, increase earnings and thereby generate value for management if compensation is tied to short-term performance measures. They further show that these agency conflicts become more prevalent in case firms sponsor large pension plans, or in case they are engaged in takeovers or need to issue securities. Rauh (2009) investigates whether risk shifting or risk management considerations drive asset allocation decisions of U.S. private DB pension funds. His findings show that better funded plans or sponsors with high credit ratings invest a larger fraction of pension assets into equities, thereby providing little evidence that risk shifting considerations drive asset allocation decisions. However, consistent with existing economic theory (Sundaresan and Zapatero, 1997; Lucas and Zeldes, 2006; Benzoni et al., 2007), he finds that the share of active plan participants is positively correlated with investment into risky securities.

Brown and Wilcox (2009) and Novy-Marx and Rauh (2011) provide evidence that U.S. public pension funds discount future pension liabilities using incorrect discount rates. Specifically, accounting guidelines published by the Government Account Standards Board (GASB) allow sponsors of U.S. public pension plans to effectively use expected return on asset assumptions when discounting future promised pension payouts. While this mechanically reduces the present value of pension liabilities and therefore artificially increases funding levels, it might also lead to distorted incentives in the asset allocation decision. In fact, Andonov et al. (2014) compare U.S. public pension funds to U.S. private plans and both private and public funds in Canada and Europe and show that U.S. public plans have increased their allocation to risky assets over the past two decades, even though interest rates have generally decreased and populations have aged over this period.

This paper contributes to the literature by investigating whether the liability management of U.S. corporate DB pension plans is distorted by opportunistic behaviour. Doing so, we provide novel evidence that underfunded plans are more likely to use any wiggle room that is provided by pension legislation in order to report lower pension liabilities. These results complement Bergstresser, Desai, and Rauh (2006) and Rauh (2009) who investigate opportunistic behaviour relating to earnings management or asset allocation decisions. In addition, our analysis shows that attempts to take advantage of the leeway to set discount rates for liability calculations are not only prevalent among public U.S. pension funds (Brown and Wilcox, 2009; Novy-Marx and Rauh, 2011) but even extend to private U.S. pension plans. Finally, we also investigate whether pension plans manipulate life expectancy assumptions.[1]

Several studies focus on the interactions between capital structure, investment and optimal pension policy. Jin, Merton, and Bodie (2006) show that the risk of a firm's pension plan affects its cost of equity and therefore suggest using a plan's assets and liabilities when computing the unlevered cost of equity. Shivdasani and Stefanescu (2010) investigate how pension liabilities affect capital structure decisions and they find that their inclusion substantially increases average leverage ratios. Given that pension contributions create a similar tax shield as interest payments and missing them can also trigger bankruptcy proceedings, their results suggest that firm's capital structure choices appear less conservative than previously assumed. Rauh (2006) investigates the impact of mandatory pension contributions to DB pension funds and finds that they substantially reduce investment. The effect is particularly strong among financially constrained firms. Bakke and Whited (2012) argue that the reduction in investment might be driven by severely underfunded plan sponsors, thereby suggesting that changes in a firm's investment opportunity set drive the strong sensitivity to mandatory pension contributions.

The findings in this paper are thus also relevant for corporate financing and investment decisions. Underfunded pension plans attempt to reduce the value of reported pension liabilities in order to reduce mandatory contributions to the pension fund. However, this funding relief can only be temporary as, at

[1] The existing literature on pension liabilities and life expectancy assumptions typically focuses on the impact of unexpected improvements in life expectancy (e.g. longevity risk) on pension liabilities. Antolin (2007) computes the effect of deterministic improvements in life expectancy on the liabilities of a hypothetical pension fund and finds that an unexpected improvement in life expectancy of one-year per decade could increase pension liabilities by 8-10 percent, depending on the age-structure of the hypothetical pension fund. Dushi, Friedberg, and Webb (2010) compute the degree to which mortality tables understate true pension liabilities for hypothetical pension funds. They find that updating mortality tables according to the Lee-Carter model – a stochastic model to forecast future mortality - would increase life expectancy at age 60 by about 3 years and pension liabilities by 12 percent.

some point, reported pension liabilities must approach its true economic value. Because accrued pension promises can only be renegotiated during bankruptcy, this means that the unreported pension liability needs to be financed (at some point). As is well known, costs associated with additional funding vary depending on the source of capital (Myers and Majluf, 1984). In the most extreme case, if existing liabilities (be it to debt holders or pensioners) are too high then external financing may become prohibitively costly (Myers, 1977).

The paper proceeds as follows. Section (2) describes the basics of pension funding law, Section (3) introduces the historical experiment and Section (4) discusses policy implications in light of the MAP-21 bill. Section (5) concludes.

2 A primer on pension funding law

Up until 2008, U.S. pension law employed two different concepts of pension liabilities (Pension Committee of the American Academy of Actuaries, 2004; Munnell and Soto, 2007). When computing the normal level of pension contributions to the pension plan (i.e. also called the normal cost), the relevant measure was the accrued pension liability (AL). The AL is an estimate of the benefits that workers earned from their past service but adjusted for future expected salary increases, calculated under assumptions set by the plan sponsor and the actuary. For example, following the Employment Retirement Income Security Act (ERISA) in 1974, plan actuaries were permitted to select a "reasonable" mortality table for determining actuarial accrued liabilities used to calculate required contributions. In addition, plan sponsors also retained substantial flexibility with regards to the underlying discount rate, as they were basically allowed to discount future liabilities using the expected return on pension assets.[2]

The second liability measure was called the current liability (CL). The CL is a measure of the benefits accrued to date (without any adjustments for future expected salary increases) using discount rates and mortality tables prescribed by law. In the past, the IRS has repeatedly introduced new rules to compute this liability measure. For example, the RPA 1994 legislation mandated the use of the GAM-83 mortality table in determining current liability and it also required Treasury to review the mortality tables every five years and update them as necessary to reflect changes and trends in pension plan experience.[3]

[2]The instructions for the Form 5500 define the valuation liability interest rate as follows: "Enter the assumption as to the expected interest rate (investment return) used to determine all the calculated values except for current liability...".

[3]Small plans (<100 employees) and multi-employer plans were not subject to the deficit reduction contribution rules but instead to the ERISA minimum funding rules, on which actuarial discretion was maintained, as it was for actuarial accrued

Treasury first updated the tables to the RP-2000 table plus the AA projection scale in 2005 for plan years beginning in 2007. The RPA 1994 legislation initially required that the discount rate must be based on a weighted average of 30-year Treasury constant maturities, but then changed the requirement for plan years beginning in 2004 to a weighted average of long-term investment grade corporate bonds.

The difference between accrued and current liabilities matters because it had an impact on the required contributions to the pension plan. Specifically, the accrued liability measure was used to compute the normal level of contributions to the pension fund. In addition, the IRS also required underfunded plans to make special deficit-reduction contributions. Those additional contributions were instead based on the current liability measure and plan sponsors had to amortize a plan's funding shortfall over a period of 30 years.

The passage of the PPA in 2006 that came into effect for plans with year ends in 2008, removed some of the wiggle room in setting actuarial assumptions. In the PPA, the Treasury prescribes by regulation both the interest rate and the mortality table to be used for all liability determinations. For mortality tables, Treasury has imposed the RP-2000 table plus the AA projection scale whereas for discount rates plan sponsors can choose between using the full (current) yield curve or a segmented yield curve concept. The segmented yield curve is based on a 24-month average of high quality corporate bonds of varying maturities. In general, the two concepts yield similar discount rates. Finally, the PPA has decreased the period for amortizing a plan's funding shortfall from 30 to 7 years.

However, in 2012 the U.S. government has signed into law the MAP-21 Act. While principally aimed at enhancing funding for several infrastructure projects, the bill also contains provisions on DB pension plans. MAP-21 provides that the segmented yield curve (which is again based on a 24-month average of yields for various maturities) has to be adjusted in case those yields deviate from their long-term historical average. To be precise, MAP-21 sets a corridor of permissible interest rates using a long-term average of 25 years. When the 24-month average falls outside the corridor, it allows the plan sponsor to use the closest point of the corridor to the 24-month average – essentially introducing a floor and a ceiling to the discount rates.[4] Because historical corporate bond yields, especially the yields in the late 80s and early 90s, were significantly higher than current yields, this adjustment increases current discount rates, which

liability calculations.

[4]The corridor started at 10 percent for 2012. In other words, for 2012, yields were subject to a floor of 90 percent of the 25-year long-term average. MAP-21 called for the corridor to increase five percentage points a year starting with 2013 until reaching 30 percent in 2016 where it was scheduled to remain indefinitely. However, recently enacted legislation in 2014 delayed the start of the increase until 2018, so the phase-in will not be complete (i.e. reach 30 percent) until 2021.

lowers the value of liabilities, thus lowering mandatory contributions. Although MAP-21 provided that the corridor first applies to plan years beginning in 2012, it gave plans that used the segmented yield curve concept the option of waiting until 2013. Pension plans using the full yield curve do not have to apply the new measures introduced in MAP-21.

3 Historical experiment

3.1 Description of pension liabilities and actuarial assumptions

This study uses the Form 5500 pension plan data filed with the U.S. DOL.[5] The information submitted to the DOL is partitioned into separate schedules and includes general information on the plan (Form 5500), actuarial information (Schedule B), financial information (Schedule H), and others.[6] Any administrator or sponsor of a plan must file this information once a year.

As summarized in detail in Appendix Table 1, the main analysis focuses on single-employer DB pension plans with at least 100 plan participants. The sample period covers the years 1999 to 2007. The starting point is motivated by the fact that as of 1999 information on important actuarial assumptions (i.e. retirement age, number of plan participants and the underlying mortality tables used in actuarial computations) are jointly available. The study ends in 2007 as this is the last year before the changes imposed by the PPA of 2006 come into effect. The final sample consists of a total of 48,880 observations (11,963 pension plans) for which information on pension liabilities, pension assets and selected actuarial assumptions are available. All variables used below are defined in Appendix Table 2.

Figure 1 compares average dollar values of current and accrued pension liabilities for our sample of 11,963 pension plans over the period from 1999 to 2007. Current liabilities hover around $90 million and exceed accrued liabilities in each single year of the sample period. This suggests that plan sponsors and actuaries employ less conservative assumptions in the computation of accrued pension liabilities. This finding is particularly interesting given that the accrued liability measure accounts for expected salary increases which, ceteris paribus, would result in a higher value of pension liabilities.

Average values obviously mask a lot of variation. We therefore compute the percentage difference between current and accrued liabilities for each pension plan at each point in time. We refer to this

[5] We use data provided by the Center of Retirement Research at Boston College.

[6] For more information on other type of information, please see IRS (2007) page 8.

difference as the liability bias measure $B_{i,t}$,

$$B_{i,t} \equiv \frac{CL_{i,t} - AL_{i,t}}{AL_{i,t}} \tag{1}$$

where CL (AL) denotes current (accrued) pension liabilities and $B_{i,t}$ is the percentage difference between them. A value of $B_{i,t}$ exceeding zero implies that accrued pension liabilities would increase by B percent if more conservative actuarial assumptions were employed. Put differently, in such a case reported pension liabilities are downward biased relative to a regulated pension liability concept. Figure 2 plots the distribution of this bias measure for our sample and shows that in most cases current liabilities exceed the accrued liability measure: the average (median) pension liability would need to be increased by approximately 10 percent (11 percent).

The difference between current and accrued pension liabilities is largely driven by different actuarial assumptions. The Form 5500 database contains detailed information on two of them: discount rates and mortality tables. It is straightforward to quantify the magnitude of different discount rate assumptions as we only need to compute the difference between the government imposed discount rate ($r_{i,t}^{CL}$) and the freely chosen one ($r_{i,t}^{AL}$):

$$r_{i,t}^{\Delta} = r_{i,t}^{CL} - r_{i,t}^{AL} \tag{2}$$

For life expectancy assumptions, the procedure is a bit more complicated. We first need to compute life expectancy under the state imposed GAM-83 mortality table and then compare it to the life expectancy under the mortality table chosen by the plan sponsor.[7] Mortality tables only contain information on expected death rates at a given age, but they can be converted into life expectancy assumptions by computing and summing up all successive multi-period survival rates (Coughlan et al., 2007). We then compute a life expectancy distortion measure by comparing life expectancy under the current liability measure ($LE_{i,t}^{CL}$) and the accrued pension liabilities ($LE_{i,t}^{AL}$)

$$LE_{i,t}^{\Delta} = LE_{i,t}^{CL} - LE_{i,t}^{AL} \tag{3}$$

[7]For our sample, pension plans have based their calculations on the (1) 1951 Group Annuity Mortality Table, (2) 1971 Group Annuity Mortality Table, (3) 1971 Individual Annuity Mortality Table, (4) the 1984 Unisex Pension Table, (5) the 1983 Individual Annuity Mortality Table, (6) the 1983 Group Annuity Mortality Table, (7) the 1994 Uninsured Pensioner Table and (8) the 2007 Mortality Table.

Figure 3 illustrates how much pension plans stretch individual actuarial assumptions. Panel A displays a frequency plot of the difference between state imposed and freely chosen discount rate assumptions (i.e. the variable $r^{\Delta}_{i,t}$ introduced in equation 2). The graph shows that pension plans consistently employ higher discount rates when left with the choice: the average (median) difference is -172 (-172) basis points. Panel B displays the difference in life expectancy assumptions (i.e. the variable $LE^{\Delta}_{i,t}$ introduced in equation 3). Here, the picture is different. Most plans employ the 1983 GAM mortality table, implying that the difference in life expectancy assumptions is zero. However, the graph illustrates that there are a few cases where pension plans employ significantly lower life expectancy assumptions.

These descriptive results show that accrued pension liabilities differ systematically from liabilities computed under the current liability measure. In addition, it seems that most of the difference is associated with a higher discount rate in the computation of the present value of pension liabilities. To more formally link life expectancy and discount rate assumptions to the difference between accrued and current pension liabilities, we estimate the following regression

$$B_{i,t} = \alpha + \beta_1 r^{\Delta}_{i,t} + \beta_2 LE^{\Delta}_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t} \tag{4}$$

where X denotes a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share invested in risky assets), γ_k is either an industry-fixed or a plan-fixed effect (in which case $k = i$) and η_t are time-fixed effects.[8] Equation 4 thus disentangles the effect of discount rate and life expectancy assumptions and further provides coefficient estimates for their partial impact.

Table 1 provides estimates under OLS and plan-fixed effect estimation. Column (1) is based on OLS estimation and shows that interest and mortality assumptions explain 26 percent of the variation of liability bias measure. Furthermore, we can see that a 10 basis points increase in the discount rate reduces the difference in liabilities by approximately 1.5 percentage points. Life expectancy assumptions also have an economically significant impact on pension liabilities: increasing the difference in life expectancy assumptions by an additional year increases the difference between current and accrued liabilities by 3.2

[8]To be precise, the Form 5500 contains a six-digit industry classification (North American Industry Classification, NAICS) and we classify plans into 19 different industries, based on the broad classification suggested by the Form 5500. In addition, we control for the size of the pension plan (measured as the logarithm of pension assets), the fraction invested into risky assets and the ratio of retired to total plan participants. The intuition is that the latter measure serves as a proxy for the duration of pension liabilities (Munnell and Soto, 2007; Rauh, 2009).

percentage points. The coefficient estimates are robust to the inclusion of plan-specific control variables (size, duration and investment in risky assets), as well as industry and year-fixed effects (see columns (2) and (3)).

Panel B displays corresponding results when accounting for plan fixed effects and therefore provide estimates for the impact of within-plan variation of the selected variables. Interestingly, this does not affect the coefficient estimate of the interest rate variable, but it does reduce somewhat the magnitude of life expectancy assumptions.

3.2 Do underfunded plans manipulate pension liabilities?

We now investigate whether the plan's funding status, measured as the relative difference between pension assets and the current liability measure, systematically affects how much accrued pension liabilities are downward biased. Figure 4 displays the non-parametric relation between the funding status of a pension plan and the percentage difference between current and accrued pension liabilities (i.e. the previously introduced bias measure B). A funding status of zero implies that pension assets match pension liabilities and that the plan is fully funded. The figure suggests that underfunded pension plans report accrued liabilities that are significantly below the current liability measure. For example, plans that are underfunded by 25 percent would need to increase the reported value of accrued pension liabilities by approximately 18 percent, whereas accrued and current liabilities are virtually the same for plans that are overfunded by 25 percent.

The univariate evidence only provides a first glance at the relation between funding status and pension liabilities. To more formally investigate whether the funding status of a pension plan affects the deviation of accrued liabilities from the regulated current liability measure, we therefore extend the previously introduced cross-sectional regression model

$$B_{i,t} = \alpha + \theta \text{funding}_{i,t} + \beta_1 r^{\Delta}_{i,t} + \beta_2 LE^{\Delta}_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t} \tag{5}$$

by including the additional variable funding (which measures the difference between the current value of pension assets and the current value of pension liabilities, relative to the current value of pension liabilities). These components are exogenous relative to the accrued liability measure. The asset allocation of pension funds is typically sticky in the short-run, implying that variation in the value of pension assets is driven by return shocks to the portfolio. In fact, for our sample, the mean (median) change in the exposure to risky assets is zero. Furthermore, the main assumptions in the computation of the current liability measure are tightly regulated, as is the degree to which pension plans can manage (or reduce) accrued benefits to future retirees (Rauh et al., 2013). The coefficient θ thus captures how sensitive the reported value of accrued pension liabilities is relative to the funding status of the pension plan.

At this point, it is crucial to emphasize that our setup is different from Rauh (2006), who uses the existence of nonlinear funding rules for underfunded pension plans to analyze the impact of mandatory pension contributions on corporate investment. The main idea in Rauh (2006) is that mandatory pension contributions are a non-linear function of the plan's funding status and are therefore uncorrelated with unobserved investment opportunities, which are typically controlled for with the mis-measured variable Tobin's Q in standard investment/cash-flow regressions (Fazzari, Hubbard, and Petersen, 1988; Erickson and Whited, 2000).[9]

In this paper, we do not use the plan's funding status as an identification mechanism because our research design is not driven by the necessity to deal with changes in the unobserved investment opportunity set. Put differently, there is no counterpart of the q-theory of investment which stipulates that the investment opportunity set affects the difference between accrued and current pension liabilities. Instead, we simply ask whether financial risk, as measured by the plan's relative funding level, affects the reported value of accrued pension liabilities.

Table (2) summarizes results when equation (5) is estimated for our sample. Panel A displays coefficients under OLS-estimation and shows that the funding level has a strong and statistically significant impact on the reported value of accrued pension liabilities. Irrespective of whether plan-specific and/or time- or industry-fixed effects are controlled for, results suggest that a 10 percentage point increase in the funding level decreases the difference between current and accrued liabilities by 1.6 percentage points. Column 4 further splits the funding level into a positive and a negative component and tests whether accrued pension liabilities respond asymmetrically to positive and negative funding levels. To ease interpretation of coefficients, negative funding levels are recorded with a positive sign (implying that a positive coefficient means that more underfunded plans suffer from a larger downward bias of pension liabilities). The coefficients on both variables are statistically significant and have the expected sign. In addition,

[9]Bakke and Whited (2012) argue that the results in Rauh (2006) are driven by severely underfunded pension plans, thereby raising the possibility that unobserved changes in investment opportunities drive investment decisions.

we can see that most of the power comes from underfunded plans: a 10 percentage point increase in the level of underfunding increases the difference between current and accrued liabilities by approximately 4 percentage points.

Before proceeding with the empirical analysis, it is helpful to discuss in more detail the relation between current liabilities, funding levels and the pension liability bias measure. Ceteris paribus, an increase in current pension liabilities decreases the funding level of the pension plan.[10] The dependent variable (B) measures the difference between two liability concepts and the empirical relation between current liabilities (and consequently funding levels) and B depends on how much accrued liabilities increase in response to the same liability shock. Equation 6 visualizes the intuition

$$\Delta B = \frac{(CL + dCL) - (AL + dAL)}{(AL + dAL)} - \frac{(CL - AL)}{AL} \tag{6}$$

In case current and accrued pension liabilities increased by the same amount (i.e. $dCL = dAL$), the bias measure B will decrease (i.e. $\Delta B < 0$) and thereby result in a positive correlation between the funding level and the bias measure B. The findings presented in Table (2) reject this possibility. Similarly, the data reject the possibility that there is no relation between the two.[11] The negative relation between the funding level and the pension liability bias measure thus means that accrued liabilities increase by less than what is required to keep the bias measure is unchanged (i.e. $dAL < \frac{AL}{CL} \times dCL$). Put differently, the liability bias measure increases in response to negative funding shocks. Appendix Table 3 further shows that this relation is also robust to using lagged funding values.

Another robustness check can be obtained by investigating the relation between funding levels and actuarial assumptions. Mortality forecasting models do not assign a role to the funding status of pension plans when forecasting future longevity. Instead, they are either based on historical mortality data (Lee and Carter, 1992), expert opinion or a combination of the two. Mortality tables are typically based on official mortality forecasts and they form the basis of corporate life expectancy assumptions. For actuarial discount rates, the law also does not give a role to financial risk measures but instead requires that the actuarial discount rate should reflect the investment return of the plan, see page 26 line 6(e) in IRS (2007).[12]

[10] Or, mathematically, $\frac{\partial \text{funding}}{\partial CL} = -\frac{CA}{CL^2} < 0$.

[11] This case would be relevant only in case accrued liabilities increased so much as to guarantee that the bias measure is unchanged, i.e. $dAL = \frac{AL}{CL} dCL$.

[12] Under ERISA, this assumption should be selected "on the basis of actuarial assumptions and methods, which, in the

From a legal perspective, neither actuarial assumptions (nor the accrued liability measure) should thus be related to the funding status of the pension plan. To test for the individual effects, we therefore estimate

$$r^{\Delta}_{i,t} = \alpha + \theta \text{funding}_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t} \quad (7)$$

$$LE^{\Delta}_{i,t} = \alpha + \theta \text{funding}_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t} \quad (8)$$

Table 3 displays corresponding results. Panel A shows that the funding level has a strong impact on the choice of the discount rate. Because the accrued liability discount rate generally exceeds the mandated discount rate (see again Panel A in Figure 3), the positive coefficient on the funding status means that this difference is reduced and plans use lower discount rates in the computation of the accrued liability measure. Most of the effect comes again from underfunded plans: if the level of underfunding increases by 10 percentage points, then the discount rate used in the accrued liability computation increases by 13 basis points. Furthermore, Panel B shows that the level of funding also affects life expectancy assumptions. Higher funding levels decrease the difference in life expectancy assumptions – better funded plans make more conservative (longer) life expectancy assumptions. Column (2) further shows that this effect is driven by underfunded pension plans.[13] Because in theory the funding level should have no impact on either of the two actuarial assumptions, the results raise the possibility that pension sponsors could manipulate the reported actuarial liability in response to funding shocks.

These results might reflect the desire of some pension sponsors to minimize pension contributions. For example, underfunded pension plans (with assets below the current liability measure) are typically mandated to make additional pension contributions (Rauh, 2006). The results suggest that sponsors of these underfunded plans are likely to use more optimistic actuarial assumptions in an attempt to reduce normal contributions, perhaps to offset the cost of the additional required contributions.

aggregate, are reasonable (taking into account the experience of the plan and reasonable expectations), and which, in combination, offer the actuarys best estimate of anticipated experience under the plan", see page 871 of ERISA (1974).

[13]Note that the fixed-effect estimates generate statistically insignificant results. We think that this may be driven by (1) the characteristics of the dependent variable and (2) the fact that fixed-effects capture within-plan variation. Firm-specific variation in life expectancy assumptions is sticky as most plans do not update or switch mortality tables. This implies that, once fixed-effects are taken care of, the within-plan variation (and thus the dependent variable) is close to zero, thereby reducing power of the fixed effect estimation.

3.3 Does credit risk drive the manipulation of pension liabilities?

The above findings show that the funding status of pension plans has an impact on the actuarial assumptions used to estimate the actuarial liability, which can reduce normal pension contributions for underfunded plans. One important question is whether this observed behavior is related to the credit risk of the plan sponsor. For example, a firm facing financial stress might be more inclined to use optimistic actuarial assumptions. This might be consistent with the notion that expected cash flows (in this case, pension payouts to plan participants) should be discounted at a rate that reflects the riskiness of the pension promises (Brown and Wilcox, 2009; Novy-Marx and Rauh, 2011). This risk is ultimately tied to the credit risk of the plan sponsor.[14]

To test whether this is the case, we now merge our sample of pension funds with firm-level data on U.S. public industrial corporations from Compustat. The match is performed using information on a firm's employment number (EIN) and the fiscal year and results in a total of 6,401 matched observations (corresponding to 952 pension plans).[15]

In a given year, a firm can sponsor multiple pension funds (the average number of pension plans per firm is two). We therefore need to adjust our pension plan variables: for each sponsor and year, we compute aggregate values of pension assets, current and accrued liabilities, retired and total plan participants and total investment into risky assets. Using the implied weights of each plan (relative to the portfolio of the plan sponsor), we also compute average values of life expectancy and discount rate assumptions.

Keeping one observation per plan sponsor in a given year reduces the total number of observations to 3,053 firm years (710 plan sponsors) but allows us to re-introduce the previously used regression model

$$B_{j,t} = \alpha + \theta \text{funding}_{j,t} + \beta_1 r^{\Delta}_{j,t} + \beta_2 LE^{\Delta}_{j,t} + \delta X_{j,t} + \lambda Y_{j,t} + \gamma_k + \eta_t + \epsilon_{j,t} \quad (9)$$

Ignoring for a moment the additional variable $Y_{j,t}$, the regression is identical to equation 5 – the only

[14]While DB pension plans are often set up as a special purpose vehicle (SPV), the underfunded component of accrued pension liabilities is still subject to the credit risk of the plan sponsor. Also note that a pension plan participant might still view the expected pension as less risky than the plan sponsor. The reason is that in case of corporate bankruptcy, pension promises are insured by the Pension Benefit Guaranty Corporation (PBGC). Technically speaking, the plan sponsor owns a put option (to sell the pension promises to the PBGC), for which it pays a periodic premium (Sharpe, 1976). However, plan participants would also not view the pension promises as fully risk-less as, for example, the PBGC only covers benefit payments up to a statutory limit (Rauh, 2009).

[15]For general information regarding matching Form 5500 data to firms in Compustat, see Gron and Madrian (2004).

difference is that the coefficients are now estimated at the level of the plan sponsor. Table 4 shows that, in this case, results are also very similar. Higher funding levels are associated with a lower percentage difference between current and accrued pension liabilities and the effect is again stronger for underfunded plan sponsors. Results are also robust to the inclusion of sponsor-specific factors, industry-, time- and firm-fixed effects.

While the similarity of results is reassuring, our main interest lies in testing whether results are robust to the inclusion of firm characteristics (captured by the variable $Y_{j,t}$) of the plan sponsor. We are specifically interested whether the downward bias in (reported) pension liabilities is driven by higher financial or operating risk. We therefore control for each sponsor's consolidated market leverage ratio, the size of the pension plan relative to the size of the plan sponsor as well as traditional factors such as firm size, a proxy for growth options and the firm's dividend yield. In addition, we follow Altman and La Fleur (1981) and compute Altman's z-score as a popular measure of a firm's credit risk (note that higher z-score values correspond to safer firms). A formal definition of all variables is provided in Appendix Table 2.[16]

Table 5 presents corresponding regression estimates. Interestingly, neither the relative size of the pension plan nor the consolidated leverage ratio of the plan sponsor are statistically significant. And while the coefficient on Altman's z-score is statistically significant (5% level OLS, 10% level fixed effects), its economic impact is small: a one unit increase in a plan's z-score decreases the downward bias on reported accrued liabilities by 0.1 to 0.2 percentage points. However, the funding status continues to be significant and underfunded pension plans report lower values of accrued pension liabilities (i.e. resulting a higher value of the bias measure).[17]

The insignificance of size and leverage is particularly surprising as both consolidated leverage ratios and the relative size of pension plans vary substantially. To illustrate, we use median values for both variables and categorize plan sponsors according to the relative size of the plan (small versus large) and the overall consolidated leverage ratios (low versus high). This classification allows us to form four different portfolios and Table 6 displays summary statistics for the three credit risk variables.

Panel A displays consolidated leverage ratios and reveals a substantial amount of variation as leverage

[16]The use of consolidated leverage ratios follows Shivdasani and Stefanescu (2010) who show that consolidation of pension assets and liabilities substantially increases market leverage ratios of firms sponsoring defined benefit pension plans.

[17]Interestingly, the existence of growth options (as measured by Tobin's q) has a statistically significant positive impact on the magnitude of the downward bias, suggesting that firms with more growth opportunities report lower values of pension liabilities. However, the economic magnitude of the effect is small.

ratios range between 17 percent and 56 percent. Interestingly, there is little variation of leverage ratios once we condition on the relative size of the pension plan. Panel B illustrates the economic magnitude of the pension plans relative to the plan sponsor. Small plans only account for 3 percent of the book assets of the plan sponsor and are thus also economically small. However, the relative size increases to up to 28 percent for large plans with high consolidated leverage ratios. Finally, Panel C mirrors the evidence of Panel A and shows that the variation in credit risk relates to the sort on consolidated leverage ratios but is largely unaffected by the relative size of the pension plan.

The construction of these portfolios allows us to test whether the average sensitivity of pension liabilities to the funding measure is robust. If credit risk was driving the downward bias of accrued pension liabilities, the sensitivity to plan underfunding should not exist for sponsors that can be considered safe. Table 7 therefore displays the sensitivity to the degree of pension underfunding and shows the coefficient estimate θ^N which is based on

$$B_{j,t} = \alpha + \theta^P \text{funding}^+_{j,t} + \theta^N \text{funding}^-_{j,t} + \beta_1 r^\Delta_{j,t} + \beta_2 LE^\Delta_{j,t} + \delta X_{j,t} + \lambda Y_{j,t} + \gamma_k + \eta_t + \epsilon_{j,t} \qquad (10)$$

Note that, as has been done throughout the paper, negative funding levels are recorded with a positive sign (implying that a positive coefficient means that more underfunded plans suffer from a larger downward bias of pension liabilities). The results clearly reject the hypothesis that plans with low measures of credit risk (i.e. low consolidated leverage ratios) do not adjust the reported value of pension liabilities downward when faced with funding shortfalls. Even for small plans with low consolidated leverage ratios, the effect is statistically and economically highly significant: increasing the level of underfunding by 10 percentage points implies an increase in the bias measure B of approximately 3.3 percentage points.

To further drive home the point that pension plans bias the reported value of pension liabilities downward even when credit risk is low, we form three additional portfolios based on a univariate sort on Altman's z-score measure (low, medium and high). Note that high (low) z-score values correspond to firms that have low (high) levels of credit risk. Table 8 presents corresponding results when estimating equation 12 for these portfolios using OLS (Panel A) and fixed-effect estimates (Panel B).

Results again show that even safe plan sponsors report lower values of pension liabilities in case they suffer from a higher level of underfunding. If anything, the impact of underfunding actually becomes stronger the less risky the plan sponsor: a 10 percentage point increase in underfunding increases the downward bias by 0-2 percentage points for plans with high credit risk, whereas the impact increases to 2-3 percentage points for firms with low credit risk.[18] Such a behaviour would be consistent with the fact that pension plans have less leeway to game the system once credit risk (and possibly outside scrutiny) increases.

As a final robustness check, we show the downward bias of pension liabilities occurs to a large degree by using higher discount rates. Table 9 therefore summarizes results of OLS (Panel A) and fixed effect (Panel B) regressions when estimating the following regression

$$r^{\Delta}_{j,t} = \alpha + \theta^P \text{funding}^+_{j,t} + \theta^N \text{funding}^-_{j,t} + \delta X_{j,t} + \lambda Y_{j,t} + \gamma_k + \eta_t + \epsilon_{j,t} \tag{11}$$

Results are displayed again separately for firms with low, medium and high levels of credit risk. It can be seen that firms that can be considered safe use considerably higher discount rates the larger the degree of plan underfunding.[19] The economic impact is substantial: a 10 percentage points increase in underfunding raises the discount rate used in the accrued liability computation by 15 to 21 basis points. Confirming the findings of Table 8, the effect weakens for plans with high levels of credit risk.

Overall our findings suggest that the level of plan funding has a strong and robust impact on the reported value of accrued pension liabilities. Specifically, we find that more underfunded plans report lower values of accrued pension liabilities. From a legal perspective, these results are surprising as actuarial assumptions should be independent from the funding status of a pension plan. From an economic perspective, the downward bias in pension liabilities of underfunded pension plans might be rational in case it reflects higher credit risk. However, our findings show that the relation persists even among plan sponsors with low level of credit risk as those sponsors employ considerably higher discount rates.

4 Policy implications and the MAP-21 bill

While the PPA of 2006 has eliminated the difference between accrued and current pension liabilities, the above findings are still highly policy relevant. At a general level, the results suggest that pension plans

[18] In fact, OLS estimation (Panel A) suggests that the downward bias increases by 2 percentage points for firms with high credit risk, whereas the fixed-effect estimation (Panel B) generates a sensitivity to underfunding that is statistically insignificant for firms with high credit risk.

[19] The interpretation follows from the fact that the accrued liability discount rate generally exceeds the mandated discount rate (implying that the dependent variable on average is negative). A positive coefficient on the negative funding level thus implies that the dependent variable becomes more negative.

are likely to use any wiggle room that is offered by the respective pension legislation in order to keep the reported value of pension liabilities as low as possible. From a pension policy perspective, this might not be desirable if such a downward bias of reported pension liabilities increases the risk of employees and retirees that the pension promises will not be met.

In 2012, the U.S. government signed into law the MAP-21 Act. This bills allows sponsors of corporate DB pension plans that use the segmented yield curve concept to effectively increase discount rates as of 2012. The reason is that under MAP-21, segment yield curves are computed over a longer period which effectively increases discount rates and thus decreases pension liabilities (see Section 2 for full details).

To illustrate the importance of our findings in the context of MAP-21, we use again Form 5500 data on corporate DB pension plans for plan-years ending in 2011 and 2012. Focusing on single-employer DB pension plans with at least 100 plan participants, this sample includes 8,105 pension plans (13,638 observations) for which information on pension liabilities, assets and contributions is available. Out of those, only 0.8 percent use the full yield curve in order to determine the discount rate underlying the computation of pension liabilities. Put differently, more than 99 percent of all plans use the segmented yield curve approach.

We then focus on the 5,218 pension plans that are available in 2012 and identify the subset of plans that switched to the MAP-21 rule in the same year. We find that 81 percent of all plans (4,239 pension plans) applied the new discount rate rules. The economic impact of the switch to the new rules is substantial as discount rates, on average, increased by 213 basis points. Consistent with our earlier findings that underfunded plans are more likely to bias the reported value of pension liabilities downward, we find that the funding status differs systematically for switching and non-switching plans. Plans that switched rules were underfunded by 8 percent in 2011 whereas non-switching plans were overfunded by 6 percent.

To more formally estimate the impact of the plan's funding status on the decision to adopt the MAP-21 legislation early, we estimate the following prediction model

$$update_{i,2012} = \alpha + \theta^P \text{funding}^+_{i,2011} + \theta^N \text{funding}^-_{i,2011} + \delta X_{i,2012} + \gamma_k + \eta_{2012} + \epsilon_{i,2012} \tag{12}$$

where $update_{i,2012}$ is a dummy variable equal to one in case the plan adopted the MAP-21 legislation in 2012, $funding^+_{i,2011}$ ($funding^-_{i,2011}$) is the positive (negative) component of the plan's funding status, X is a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share invested in risky assets) and γ_k is an industry-fixed effect.[20]

Table 10 shows that the funding level in the year preceding the earliest possible adoption has a significant impact on the switching decision: plans that are more underfunded are significantly more likely to adopt the MAP-21 legislation already in 2012. These results are consistent with our earlier findings and highlight the policy relevance of our results: pension funds – when in need and left with the choice – are more likely to use the wiggle room granted by pension legislation in order to keep the reported value of pension liabilities low.

The effect on mandatory pension contributions followed immediately: mandatory pension contributions decreased by 37 percent for switching pension plans, whereas they increased by 33 percent for those plans that postponed adoption of MAP-21 until 2013.

5 Conclusion

The analysis presented in this paper suggests that pension funds – when left with the choice – manipulate pension liabilities downward. The finding is based on a historical experiment of 11,963 U.S. corporate DB pension plans over the period from 1999 to 2007. During the sample period, the IRS distinguished between two alternative pension liability concepts: a current liability measure, which is based on state imposed discount rates and mortality tables, and an accrued liability measure. For the latter, the actuary and plan sponsor could choose the appropriate discount rate and mortality assumptions. Our analysis reveals that the reported value of accrued pension liabilities would need to be increased by 10 percent in order to keep up with the government mandated pension liability measure. Perhaps most importantly, we find that the effect is strongest for underfunded pension plans.

While the PPA eliminated the co-existence of the two liability measures in 2008, our results continue to be highly relevant. In 2012, the U.S. government signed into law the MAP-21 Act. Loosely speaking, the bill gives sponsors of DB pension plans the option of using higher discount rates when computing the present value of pension liabilities. Plans had the option of implementing the legislation immediately in 2012 and we show that underfunded plans were substantially more likely to make use of it. The benefit of the adoption followed immediately: mandatory pension contributions decreased by 37 percent for pension plans that switched to the new rule, whereas they increased by 33 percent for those plans that postponed

[20]Similar to before, negative funding levels are recorded with a positive sign implying that a positive coefficient means that more underfunded plans are more likely to be early adopters of the new legislation.

adoption of MAP-21 until 2013.

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Figure 1: **Comparison of current and accrued pension liabilities**

The figure plots the annual average current (CL) and accrued (AL) pension liability. Variables are defined in Appendix Table 2. Sample of 11,963 U.S. single employer defined benefit pension plans and 48,880 plan-years, 1999-2007.

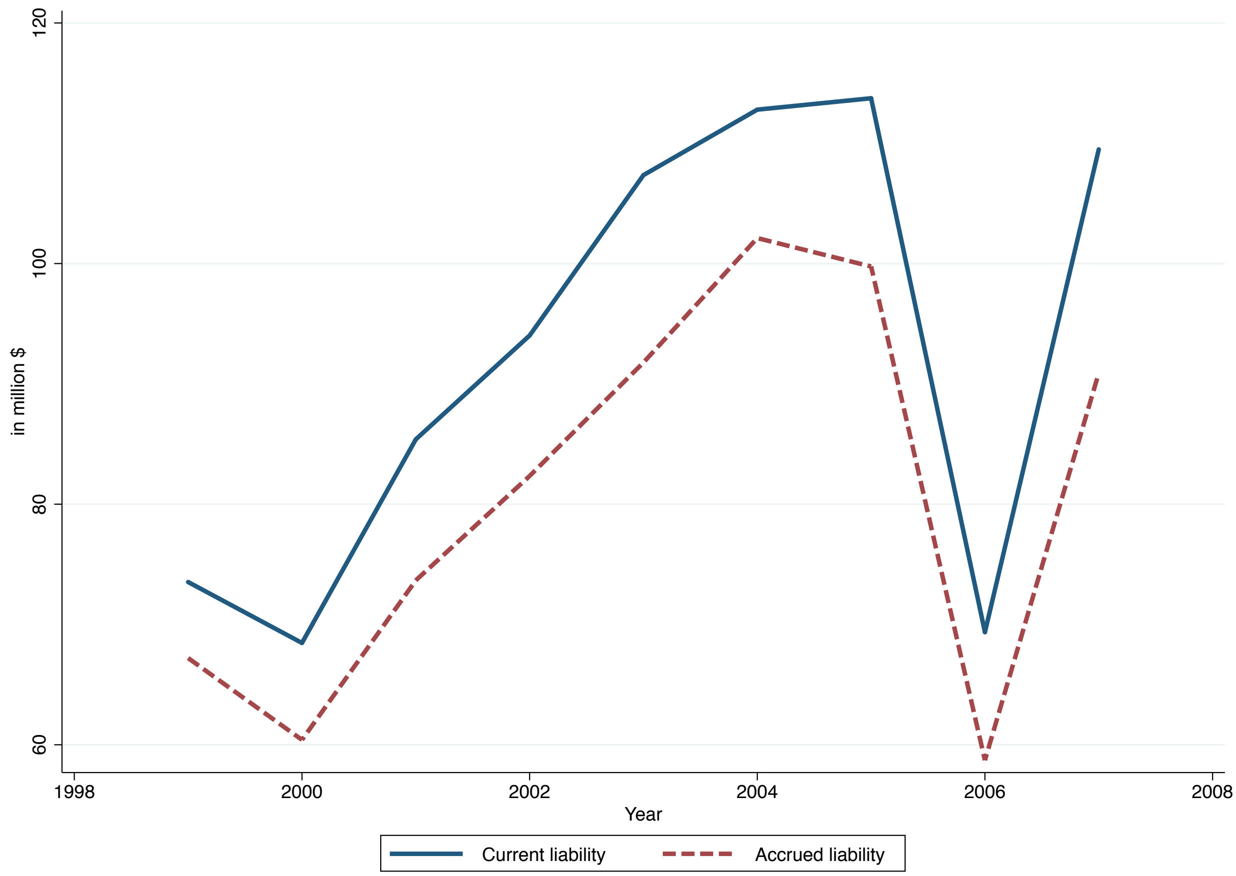


Figure 2: **Distribution of pension liability bias**

The figure plots the distribution of the pension liability bias measure B, where

$$B_{i,t} \equiv \frac{CL_{i,t} - AL_{i,t}}{AL_{i,t}}$$

and CL (AL) denotes the value of current (accrued) pension liabilities. Variables are defined in Appendix Table 2. Sample of 11,963 U.S. single employer defined benefit pension plans and 48,880 plan-years, 1999-2007.

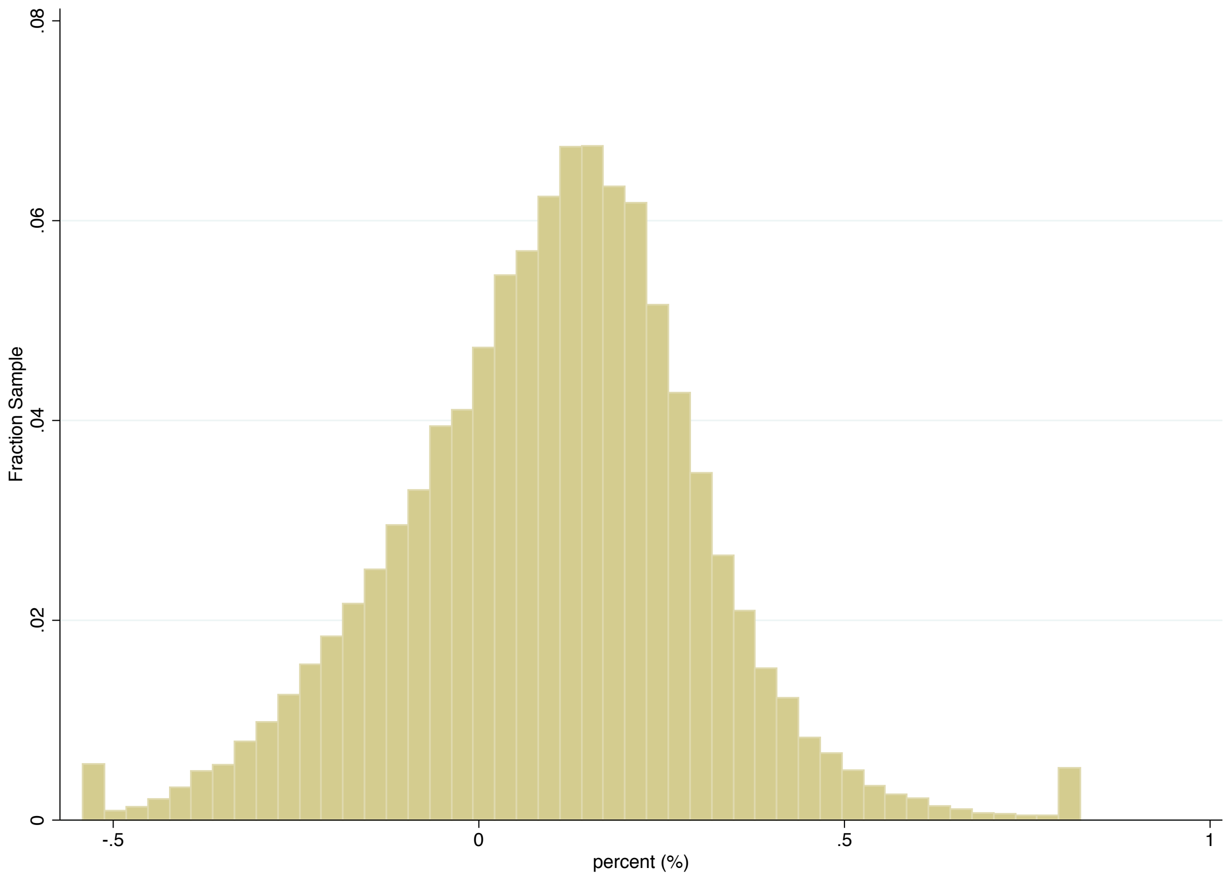
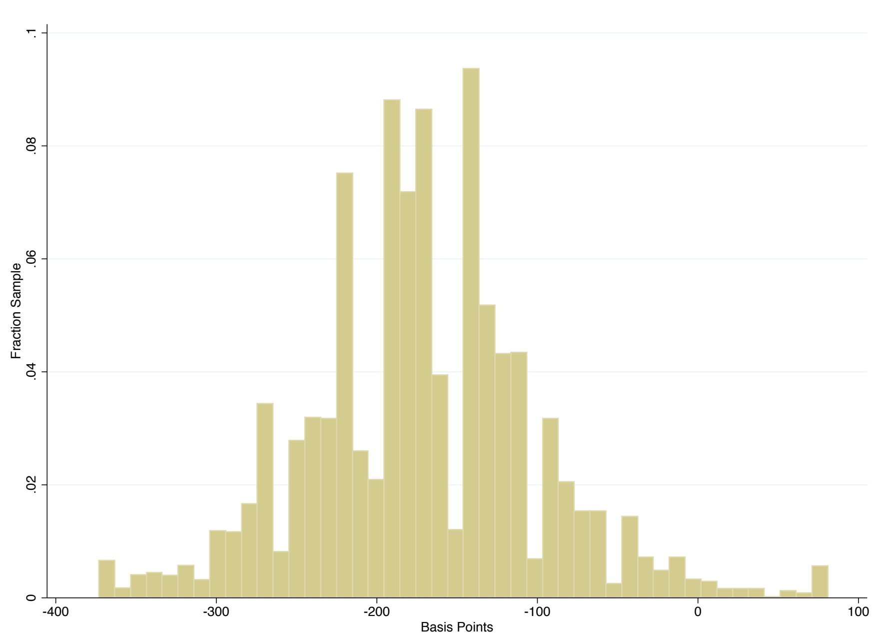


Figure 3: **Difference in actuarial assumptions**

The figure plots the difference in actuarial assumptions used under the current liability (CL) and the accrued liability (AL) measure. Panel A is based on the difference in discount rate assumptions ($r^{\Delta}_{i,t} = r^{CL}_{i,t} - r^{AL}_{i,t}$ where $r^{CL}_{i,t}$ ($r^{AL}_{i,t}$) is the discount rate assumptions under the CL (AL) measure). Panel B is based on the difference in life expectancy assumptions ($LE^{\Delta}_{i,t} = LE^{CL}_{i,t} - LE^{AL}_{i,t}$ where $LE^{CL}_{i,t}$ ($LE^{AL}_{i,t}$) is the life expectancy assumption under the CL (AL) measure). Variables are defined in Appendix Table 2. Sample of 11,963 U.S. single employer defined benefit pension plans and 48,880 plan-years, 1999-2007.

Panel A: Difference in interest rate assumptions



Panel B: Difference in life expectancy assumptions

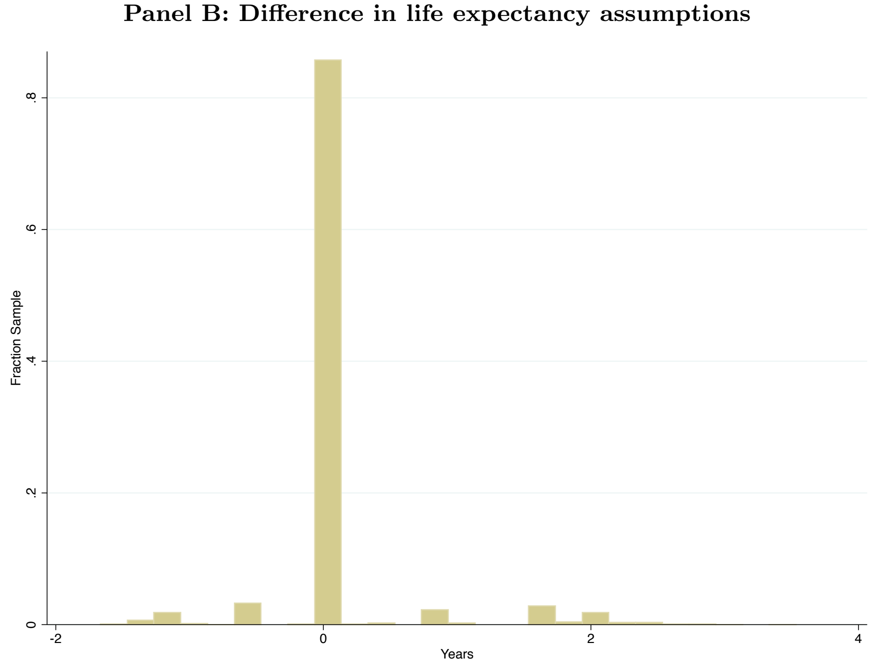


Figure 4: **Relation between pension liability bias and funding status**

The figure plots the univariate relation between the funding status (horizontal axis) and the pension liability measure B, i.e. percentage difference between current (CL) and accrued liabilities (AL). Funding status is defined as the difference between pension assets and pension liabilities, measured relative to pension liabilities. The kernel regression estimation is performed using an Epanechnikov kernel, with a bandwith of 0.1. A 95% confidence interval is included in the shaded region. Variables are defined in Appendix Table 2. Sample of 11,963 U.S. single employer defined benefit pension plans and 48,880 plan-years, 1999-2007.

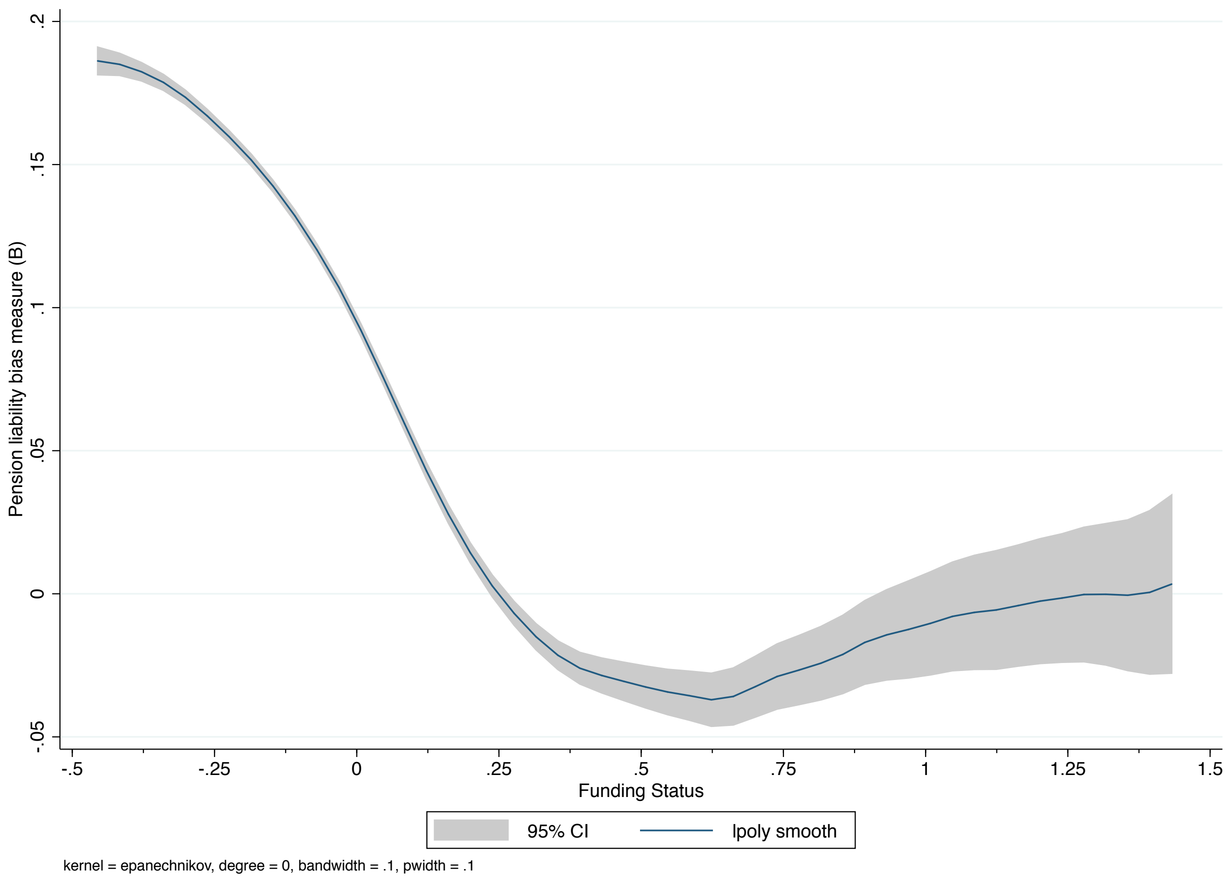


Table 1: **The impact of actuarial assumptions on pension liabilities**

This table displays results when estimating the effect of actuarial assumptions on the bias variable $B_{i,t}$, which is defined as the relative difference between current pension liabilities (CL) and accrued pension liabilities (AL). The regression is given by

$$B_{i,t} = \alpha + \beta_1 r^{\Delta}_{i,t} + \beta_2 LE^{\Delta}_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t}$$

where $r^{\Delta}_{i,t}$ denotes the difference in discount rate assumptions ($r^{\Delta}_{i,t} = r^{CL}_{i,t} - r^{AL}_{i,t}$), $LE^{\Delta}_{i,t}$ the difference in life expectancy assumptions ($LE^{\Delta}_{i,t} = LE^{CL}_{i,t} - LE^{AL}_{i,t}$), $X_{i,t}$ denotes a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share of risky assets), γ_k is either an industry-fixed or a plan-fixed effect (in which case $k = i$) and η_t are time-fixed effects. The estimation is done using both OLS-estimation (Panel A) and by accounting for plan-fixed effects (Panel B). Standard errors are adjusted for heteroskedasticity. Details on sample selection criteria are in Appendix Table 1, detailed variable definitions are in Appendix Table 2. Sample of 11,963 U.S. single employer defined benefit pension plans and 48,880 plan-years, 1999-2007.

Control Variables	(1)	(2)	(3)
Panel A: OLS Estimation			
$r^{\Delta}_{i,t}$	-0.0015***	-0.0015***	-0.0014***
$LE^{\Delta}_{i,t}$	0.0321***	0.0290***	0.0289***
size		-0.0120***	-0.0089***
duration		0.2316***	0.1852***
risky		0.0241***	0.0118**
time dummies	no	no	yes
industry dummies	no	no	yes
N	48880	48880	48880
R^2	0.2619	0.2994	0.3386
Panel B: Fixed Effect Estimation			
$r^{\Delta}_{i,t}$			-0.0014***
$LE^{\Delta}_{i,t}$	0.0165***	0.0187***	0.0223***
size		0.0300***	-0.0041
duration		0.1117***	0.0086
risky		0.0021	0.0046
time dummies	no	no	yes
industry dummies	no	no	no
N	48880	48880	48880
R^2	0.31	0.3197	0.3559

Table 2: **The additional impact of the funding status on pension liabilities**

This table displays results when estimating the partial effect of the funding status on the bias variable $B_{i,t}$, which is defined as the relative difference between current pension liabilities (CL) and accrued pension liabilities (AL). The regression is given by

$$B_{i,t} = \alpha + \theta \text{funding}_{i,t} + \beta_1 r^{\Delta}_{i,t} + \beta_2 LE^{\Delta}_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t}$$

where funding is measured as the difference between the current value of pension assets and the current value of pension liabilities (relative to the current value of pension liabilities), $r^{\Delta}_{i,t}$ denotes the difference in discount rate assumptions ($r^{\Delta}_{i,t} = r^{CL}_{i,t} - r^{AL}_{i,t}$), $LE^{\Delta}_{i,t}$ the difference in life expectancy assumptions ($LE^{\Delta}_{i,t} = LE^{CL}_{i,t} - LE^{AL}_{i,t}$), $X_{i,t}$ is a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share invested in risky assets), γ_k is either an industry-fixed or a plan-fixed effect (in which case $k = i$) and η_t are time-fixed effects. In column (4), the funding level is split into a positive (overfunded) and negative (underfunded) component (which records negative funding levels with a positive sign). The estimation is done using both OLS-estimation (Panel A) and by accounting for plan-fixed effects (Panel B). Standard errors are adjusted for heteroskedasticity. Details on sample selection criteria are in Appendix Table 1, detailed variable definitions are in Appendix Table 2. Sample of 11,963 U.S. single employer defined benefit pension plans and 48,880 plan-years, 1999-2007.

Control Variables	(1)	(2)	(3)	(4)
Panel A: OLS Estimation				
funding_{it}	-0.1623***	-0.1622***	-0.1645***	
$r^{\Delta}_{i,t}$	-0.0014***	-0.0013***	-0.0013***	-0.0012***
$LE^{\Delta}_{i,t}$	0.0271***	0.0274***	0.0253***	0.0238***
$\text{size}_{i,t}$		-0.0039***	-0.0009+	0.0019***
$\text{duration}_{i,t}$		0.2201***	0.1848***	0.1753***
$\text{risky}_{i,t}$		0.0378***	0.0272***	0.0346***
funding^{+}_{it}				-0.1119***
funding^{-}_{it}				0.3730***
time dummies	yes	yes	yes	yes
industry dummies	yes	yes	yes	yes
N	48880	48880	48880	48880
R^2	0.3274	0.3606	0.3934	0.4048
Panel B: Fixed Effect Estimation				
funding_{it}	-0.1480***	-0.1705***	-0.1918***	
$r^{\Delta}_{i,t}$	-0.0013***	-0.0013***	-0.0011***	-0.0011***
$LE^{\Delta}_{i,t}$	0.0189***	0.0230***	0.0212***	0.0213***
$\text{size}_{i,t}$		0.0590***	0.0417***	0.0455***
$\text{duration}_{i,t}$		0.0527***	0.0240*	0.0221*
$\text{risky}_{i,t}$		0.0126*	0.0127*	0.0150**
funding^{+}_{it}				-0.1812***
funding^{-}_{it}				0.2353***
time dummies	yes	yes	yes	yes
industry dummies	no	no	no	no
N	48880	48880	48880	48880
R^2	0.3703	0.3936	0.4191	0.42

Table 3: **The impact of the funding status on actuarial assumptions**

This table displays results when estimating the partial effect of the funding status on actuarial assumptions. The regression is given by

$$y_{i,t} = \alpha + \theta \text{funding}_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t}$$

where $y_{i,t} = r^{\Delta}_{i,t}$ in Panel A and $y_{i,t} = LE^{\Delta}_{i,t}$ in Panel B. Funding is measured as the difference between the current value of pension assets and the current value of pension liabilities (relative to the current value of pension liabilities), $X_{i,t}$ is a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share invested in risky assets), γ_k is either an industry-fixed or a plan-fixed effect (in which case $k = i$) and η_t are time-fixed effects. In columns (2 and 4), the funding level is split into a positive (overfunded) and negative (underfunded) component (which records negative funding levels with a positive sign). The estimation is done using both OLS-estimation (Panel A) and by accounting for plan-fixed effects (Panel B). Standard errors are adjusted for heteroskedasticity. Details on sample selection criteria are in Appendix Table 1, detailed variable definitions are in Appendix Table 2. Sample of 11,963 U.S. single employer defined benefit pension plans and 48,880 plan-years, 1999-2007.

	OLS estimation		Fixed effect estimation	
Control Variables	(1)	(2)	(3)	(4)
Panel A: $r^{\Delta}_{i,t} = \alpha + \theta \text{funding}_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t}$				
funding_{it}	47.0601***		55.5848***	
$\text{size}_{i,t}$	-14.5320***	-15.4149***	-15.8555***	-22.1382***
$\text{duration}_{i,t}$	7.3173***	11.2562***	-5.8712	-2.3648
$\text{risky}_{i,t}$	-30.3077***	-32.9311***	-3.3369	-7.3814***
funding^{+}_{it}		23.7623***		35.6027***
funding^{-}_{it}		-134.1231***		-131.5453***
time dummies	yes	yes	yes	yes
industry dummies	yes	yes	no	no
N	48880	48880	48880	48880
R^2	0.2106	0.2274	0.2686	0.2859
Panel B: $LE^{\Delta}_{i,t} = \alpha + \theta \text{funding}_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t}$				
funding_{it}	-0.0560***		-0.0332**	
$\text{size}_{i,t}$	-0.0328***	-0.0314***	-0.0203*	-0.0227*
$\text{duration}_{i,t}$	0.1172***	0.1111***	0.0277	0.0291
$\text{risky}_{i,t}$	-0.2238***	-0.2198***	0.0006	-0.0010
funding^{+}_{it}		-0.0198*		-0.0408**
funding^{-}_{it}		0.1913***		0.0043
time dummies	yes	yes	yes	yes
industry dummies	yes	yes	no	no
N	48880	48880	48880	48880
R^2	0.0372	0.038	0.0192	0.0192

Table 4: **The impact of the funding status on pension liabilities of plan sponsors**

This table displays results when estimating the partial effect of the funding status on the bias variable $B_{j,t}$, which is defined as the relative difference between current pension liabilities (CL) and accrued pension liabilities (AL). The regression is performed at the level of the plan sponsor and is given by

$$B_{j,t} = \alpha + \theta \text{funding}_{j,t} + \beta_1 r^{\Delta}_{j,t} + \beta_2 LE^{\Delta}_{j,t} + \delta X_{j,t} + \gamma_k + \eta_t + \epsilon_{j,t}$$

where funding is measured as the difference between the current value of pension assets and the current value of pension liabilities (relative to the current value of pension liabilities), $r^{\Delta}_{j,t}$ denotes the difference in discount rate assumptions ($r^{\Delta}_{j,t} = r^{CL}_{j,t} - r^{AL}_{j,t}$), $LE^{\Delta}_{j,t}$ the difference in life expectancy assumptions ($LE^{\Delta}_{j,t} = LE^{CL}_{j,t} - LE^{AL}_{j,t}$), $X_{j,t}$ is a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share invested in risky assets), γ_k is either an industry-fixed or a sponsor-fixed effect (in which case $k = j$) and η_t are time-fixed effects. In column (4), the funding variable is split into a positive (overfunded) and negative (underfunded) component (which records negative funding levels with a positive sign). The estimation is done using both OLS-estimation (Panel A) and by accounting for sponsor-fixed effects (Panel B). Standard errors are adjusted for heteroskedasticity. Details on sample selection criteria are in Appendix Table 4, detailed variable definitions and an explanation of the aggregation procedure are in Appendix Table 2. Sample of 707 U.S. single employer defined benefit pension plan sponsors and 3,038 plan-years, 1999-2007.

Control Variables	(1)	(2)	(3)	(4)
Panel A: OLS Estimation				
$\text{funding}_{j,t}$	-0.1103***	-0.1108***	-0.1209***	
$r^{\Delta}_{j,t}$	-0.0012***	-0.0012***	-0.0012***	-0.0011***
$LE^{\Delta}_{j,t}$	0.0106	0.0084	0.0104	0.0097
$\text{size}_{j,t}$		-0.0046**	-0.0040*	-0.0015
$\text{duration}_{j,t}$		0.0836***	0.1045***	0.0982***
$\text{risky}_{j,t}$		0.0678***	0.0749***	0.0815***
$\text{funding}^{+}_{j,t}$				-0.0808***
$\text{funding}^{-}_{j,t}$				0.3161***
time dummies	yes	yes	yes	yes
industry dummies	yes	yes	yes	yes
N	3053	3053	3053	3053
R^2	0.3065	0.3182	0.3591	0.3705
Panel B: Fixed Effect Estimation				
$\text{funding}_{j,t}$	-0.1255***	-0.1225***	-0.1543***	
$r^{\Delta}_{j,t}$	-0.0012***	-0.0012***	-0.0011***	-0.0011***
$LE^{\Delta}_{j,t}$	0.0396***	0.0350***	0.0380***	0.0378***
$\text{size}_{j,t}$		-0.0158**	-0.0155**	-0.0143*
$\text{duration}_{j,t}$		0.0508+	0.0379	0.0363
$\text{risky}_{j,t}$		0.0256	0.0273	0.0312
$\text{funding}^{+}_{j,t}$				-0.1468***
$\text{funding}^{-}_{j,t}$				0.2036***
time dummies	yes	yes	yes	yes
industry dummies	no	no	no	no
N	3053	3053	3053	3053
R^2	0.3835	0.3929	0.4305	0.4314

Table 5: **The impact of firm characteristics on pension liabilities of plan sponsors**

This table displays results when estimating the partial effect of the funding status and selected firm characterstics on the bias variable $B_{j,t}$, which is defined as the relative difference between current pension liabilities (CL) and accrued pension liabilities (AL). The regression is performed at the level of the plan sponsor and is given by

$$B_{j,t} = \alpha + \theta \text{funding}_{j,t} + \beta_1 r^{\Delta}_{j,t} + \beta_2 LE^{\Delta}_{j,t} + \delta X_{j,t} + \lambda Y_{j,t} + \gamma_k + \eta_t + \epsilon_{j,t}$$

where funding is measured as the difference between the current value of pension assets and the current value of pension liabilities (relative to the current value of pension liabilities), $r^{\Delta}_{j,t}$ denotes the difference in discount rate assumptions ($r^{\Delta}_{j,t} = r^{CL}_{j,t} - r^{AL}_{j,t}$), $LE^{\Delta}_{j,t}$ the difference in life expectancy assumptions ($LE^{\Delta}_{j,t} = LE^{CL}_{j,t} - LE^{AL}_{j,t}$), $X_{j,t}$ is a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share invested in risky assets), $Y_{j,t}$ is a vector of sponsor specific control variables (relative size of pension plans relative to plan sponsor, consolidated leverage ratio, Altman's z-score, Tobin's Q and dividend yield), γ_k is either an industry-fixed or a sponsor-fixed effect (in which case $k = j$) and η_t are time-fixed effects. In column (4), the funding variable is split into a positive (overfunded) and negative (underfunded) component (which records negative funding levels with a positive sign). The estimation is done using both OLS-estimation (Panel A) and by accounting for sponsor-fixed effects (Panel B). Standard errors are adjusted for heteroskedasticity. Details on sample selection criteria are in Appendix Table 4, detailed variable definitions are in Appendix Table 2. Sample of 707 U.S. single employer defined benefit pension plan sponsors and 2,782 plan-years, 1999-2007.

	OLS		Fixed effects	
Control variables	(1)	(2)	(3)	(4)
$\text{funding}_{j,t}$	-0.1090***		-0.1461***	
$r^{\Delta}_{j,t}$	-0.0012***	-0.0012***	-0.0011***	-0.0011***
$LE^{\Delta}_{j,t}$	0.0049	0.0042	0.0368***	0.0367***
$\text{size}_{j,t}$	-0.0052**	-0.0028	-0.0183**	-0.0169**
$\text{duration}_{j,t}$	0.1145***	0.1111***	0.0433	0.0420
$\text{risky}_{j,t}$	0.0597***	0.0662***	0.0264	0.0303
rel. $\text{Size}_{j,t}$	0.0073	0.0107	0.0477	0.0447
$\text{leverage}_{j,t}$	-0.0078	-0.0207	-0.0159	-0.0170
$\text{Z-score}_{j,t}$	-0.0011*	-0.0011*	-0.0016+	-0.0016+
$Q_{j,t}$	0.0142**	0.0127**	0.0092+	0.0091+
$\text{dividend}_{j,t}$	-0.2362*	-0.2118+	0.0392	0.0423
$\text{funding}^{+}_{j,t}$		-0.0717***		-0.1385***
$\text{funding}^{-}_{j,t}$		0.2982***		0.1953***
time dummies	yes	yes	yes	yes
industry dummies	yes	yes	no	no
N	2797	2797	2797	2797
R^2	0.3603	0.3709	0.3995	0.4005

Table 6: **Portfolios formed on consolidated leverage ratio and relative size of pension plans**

This table displays descriptive information on selected credit risk variables (consolidated leverage ratio, relative size of the pension plan and Altman's z-score). Plan sponsors are grouped into four portfolios using median values of consolidated leverage ratios (low versus high) and the relative size of the pension plan (small versus large) as cut-off points. Panel A displays average values for consolidated leverage ratios, Panel B shows average values of the relative size of the pension plans and Panel C displays average values of Altman's z-score measure. Details on sample selection criteria are in Appendix Table 4, detailed variable definitions are in Appendix Table 2. Sample of 707 U.S. single employer defined benefit pension plan sponsors and 2,782 plan-years, 1999-2007.

Size / Leverage	Low	High	All
Panel A: Consolidated leverage ratios			
Small	0.17	0.54	0.32
Large	0.20	0.56	0.41
All	0.18	0.55	0.37
Panel B: Relative size of pension plans			
Small	0.03	0.03	0.03
Large	0.17	0.28	0.23
All	0.09	0.18	0.13
Panel C: Altman's z-score			
Small	9.23	2.33	6.36
Large	10.72	3.59	6.56
All	9.85	3.07	6.46

Table 7: **The impact of negative funding status for different portfolios**

This table displays results when estimating the partial effect of the negative funding status on the bias variable $B_{j,t}$, which is defined as the relative difference between current pension liabilities (CL) and accrued pension liabilities (AL). The regression is performed at the level of the plan sponsor and is given by

$$B_{j,t} = \alpha + \theta^P \text{funding}^+_{j,t} + \theta^N \text{funding}^-_{j,t} + \beta_1 r^\Delta_{j,t} + \beta_2 LE^\Delta_{j,t} + \delta X_{j,t} + \lambda Y_{j,t} + \gamma_k + \eta_t + \epsilon_{j,t}$$

where funding is measured as the difference between the current value of pension assets and the current value of pension liabilities (relative to the current value of pension liabilities), $r^\Delta_{j,t}$ denotes the difference in discount rate assumptions ($r^\Delta_{j,t} = r^{CL}_{j,t} - r^{AL}_{j,t}$), $LE^\Delta_{j,t}$ the difference in life expectancy assumptions ($LE^\Delta_{j,t} = LE^{CL}_{j,t} - LE^{AL}_{j,t}$), $X_{j,t}$ is a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share invested in risky assets), $Y_{j,t}$ is a vector of sponsor specific control variables (relative size of pension plans relative to plan sponsor, consolidated leverage ratio, Altman's z-score, Tobin's Q and dividend yield), γ_k is either an industry-fixed or a sponsor-fixed effect (in which case $k = j$) and η_t are time-fixed effects. The funding status is split into a positive (overfunded) and negative (underfunded) component (which records negative funding levels with a positive sign) and the table below only reports the sensitivity measure θ^N . Results are grouped by the relative size of the pension plan (small versus large) and the consolidated leverage ratio (low versus high). The estimation is done using both OLS-estimation (Panel A) and by accounting for sponsor-fixed effects (Panel B). Standard errors are adjusted for heteroskedasticity. Details on sample selection criteria are in Appendix Table 4, detailed variable definitions are in Appendix Table 2. Sample of 707 U.S. single employer defined benefit pension plan sponsors and 2,782 plan-years, 1999-2007.

Size / Leverage	Low	High	All
Panel A: OLS Estimation			
Small	0.33	0.32	0.33
Large	0.36	0.25	0.29
All	0.34	0.28	0.31
Panel B: Fixed Effect Estimation			
Small	0.18	0.00	0.11
Large	0.27	0.22	0.24
All	0.22	0.13	0.17

Table 8: **Altman's z-score and the impact of the funding status on pension liabilities of plan sponsors**

This table displays results when estimating the partial effect of the funding status on the bias variable $B_{j,t}$, which is defined as the relative difference between current pension liabilities (CL) and accrued pension liabilities (AL). The regression is performed at the level of the plan sponsor and is given by

$$B_{j,t} = \alpha + \theta^P \text{funding}^+_{j,t} + \theta^N \text{funding}^-_{j,t} + \beta_1 r^\Delta_{j,t} + \beta_2 LE^\Delta_{j,t} + \delta X_{j,t} + \lambda Y_{j,t} + \gamma_k + \eta_t + \epsilon_{j,t}$$

where funding is measured as the difference between the current value of pension assets and the current value of pension liabilities (relative to the current value of pension liabilities) and the funding status is split into a positive (overfunded) and negative (underfunded) component (which records negative funding levels with a positive sign). The variable $r^\Delta_{j,t}$ denotes the difference in discount rate assumptions ($r^\Delta_{j,t} = r^{CL}_{j,t} - r^{AL}_{j,t}$), $LE^\Delta_{j,t}$ the difference in life expectancy assumptions ($LE^\Delta_{j,t} = LE^{CL}_{j,t} - LE^{AL}_{j,t}$), $X_{j,t}$ is a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share invested in risky assets), $Y_{j,t}$ is a vector of sponsor specific control variables (relative size of pension plans relative to plan sponsor, consolidated leverage ratio, Altman's z-score, Tobin's Q and dividend yield), γ_k is either an industry-fixed or a sponsor-fixed effect (in which case $k = j$) and η_t are time-fixed effects. The estimation is done using both OLS-estimation (Panel A) and by accounting for sponsor-fixed effects (Panel B). Standard errors are adjusted for heteroskedasticity. Details on sample selection criteria are in Appendix Table 4, detailed variable definitions are in Appendix Table 2. Sample of 707 U.S. single employer defined benefit pension plan sponsors and 2,782 plan-years, 1999-2007.

	Altman's z-score		
Control Variables	Low	Medium	High
Panel A: OLS Estimation			
$\text{funding}^+_{j,t}$	-0.0614*	-0.0954**	-0.0633*
$\text{funding}^-_{j,t}$	0.2017***	0.3668***	0.3335***
$r^\Delta_{j,t}$	-0.0012***	-0.0010***	-0.0012***
$LE^\Delta_{j,t}$	0.0227+	0.0065	-0.0073
$\text{size}_{j,t}$	-0.0044	-0.0003	-0.0028
$\text{duration}_{j,t}$	0.0978**	0.1194***	0.0988***
$\text{risky}_{j,t}$	0.0792*	0.0364	0.0893**
rel. $\text{Size}_{j,t}$	0.0207	0.041	0.0732+
$\text{leverage}_{j,t}$	-0.0095	-0.1625**	-0.0537
$\text{Z-score}_{j,t}$	0.0131+	-0.0048	-0.0002
$Q_{j,t}$	0.0116	0.0073	0.0132*
$\text{dividend}_{j,t}$	0.1667	-0.2473	-1.2007**
time dummies	yes	yes	yes
industry dummies	yes	yes	yes
N	923	923	951
R^2	0.33	0.45	0.41
Panel B: Fixed Effect Estimation			
$\text{funding}^+_{j,t}$	-0.1168	-0.1712***	-0.1578*
$\text{funding}^-_{j,t}$	0.0714	0.2189***	0.1867**
$r^\Delta_{j,t}$	-0.0009***	-0.0011***	-0.0013***
$LE^\Delta_{j,t}$	0.0297**	0.0503**	0.0368**
$\text{size}_{j,t}$	-0.0250*	-0.0079	-0.0213+
$\text{duration}_{j,t}$	0.0372	0.0264	0.0415
$\text{risky}_{j,t}$	0.0209	0.0196	0.0664*
rel. $\text{Size}_{j,t}$	0.1209+	-0.0597	0.2360*
$\text{leverage}_{j,t}$	-0.0273	0.017	-0.1057
$\text{Z-score}_{j,t}$	0.0095	0.0022	-0.0026*
$Q_{j,t}$	0.0044	0.0256	0.0086
$\text{dividend}_{j,t}$	0.1535	-0.3589+	0.2905
time dummies	yes	yes	yes
industry dummies	no	no	no
N	923	923	951
R^2	0.303	0.5209	0.4922

Table 9: **Altman's z-score and the impact of the funding status on discount rates assumptions**

This table displays results when estimating the partial effect of the funding level on the bias variable $B_{j,t}$, which is defined as the relative difference between current pension liabilities (CL) and accrued pension liabilities (AL). The regression is performed at the level of the plan sponsor and is given by

$$r^{\Delta}_{j,t} = \alpha + \theta^P \text{funding}^+_{j,t} + \theta^N \text{funding}^-_{j,t} + \delta X_{j,t} + \lambda Y_{j,t} + \gamma_k + \eta_t + \epsilon_{j,t}$$

where funding is measured as the difference between the current value of pension assets and the current value of pension liabilities (relative to the current value of pension liabilities) and the funding status is split into a positive (overfunded) and negative (underfunded) component (which records negative funding levels with a positive sign). The variable $r^{\Delta}_{j,t}$ denotes the difference in discount rate assumptions ($r^{\Delta}_{j,t} = r^{CL}_{j,t} - r^{AL}_{j,t}$), $X_{j,t}$ is a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share invested in risky assets), $Y_{j,t}$ is a vector of sponsor specific control variables (relative size of pension plans relative to plan sponsor, consolidated leverage ratio, Altman's z-score, Tobin's Q and dividend yield), γ_k is either an industry-fixed or a sponsor-fixed effect (in which case $k = j$) and η_t are time-fixed effects. The estimation is done using both OLS-estimation (Panel A) and by accounting for sponsor-fixed effects (Panel B). Standard errors are adjusted for heteroskedasticity. Details on sample selection criteria are in Appendix Table 4, detailed variable definitions are in Appendix Table 2. Sample of 707 U.S. single employer defined benefit pension plan sponsors and 2,782 plan-years, 1999-2007.

	Altman's z-score		
Control Variables	Low	Medium	High
Panel A: OLS Estimation			
$\text{funding}^+_{j,t}$	38.2940***	31.5676**	44.7522***
$\text{funding}^-_{j,t}$	-67.1642**	-170.3663***	-146.4177***
$\text{size}_{j,t}$	-15.4022***	-17.7922***	-14.9190***
$\text{duration}_{j,t}$	21.7373	40.5817**	43.5839**
$\text{risky}_{j,t}$	-14.3312	-11.3356	-27.0201*
rel. $\text{Size}_{j,t}$	-4.4528	-23.1177	-40.4129
$\text{leverage}_{j,t}$	2.4111	7.2205	41.3133
Z-$\text{score}_{j,t}$	-5.7260*	-4.4235	-0.4626
$Q_{j,t}$	-3.6794	0.5152	-2.5133
$\text{dividend}_{j,t}$	9.8658	-171.0883+	192.5492
time dummies	yes	yes	yes
industry dummies	yes	yes	yes
N	923	923	951
R^2	0.3237	0.3023	0.3027
Panel B: Fixed Effect Estimation			
$\text{funding}^+_{j,t}$	27.6218	33.9559*	25.2314
$\text{funding}^-_{j,t}$	-51.1272	-285.8554***	-208.3540***
$\text{size}_{j,t}$	-6.8479	-12.0689*	-14.5513*
$\text{duration}_{j,t}$	21.4479	13.6156	-37.6158
$\text{risky}_{j,t}$	-9.5746	-44.2666	-39.4582*
rel. $\text{Size}_{j,t}$	-51.0338	-52.4525	-29.9724
$\text{leverage}_{j,t}$	-36.9978	4.0199	-40.9850
Z-$\text{score}_{j,t}$	-10.9238*	-4.077	-0.3617
$Q_{j,t}$	15.9956	14.5826	4.2756
$\text{dividend}_{j,t}$	-76.4417	-34.5468	216.3877
time dummies	yes	yes	yes
industry dummies	no	no	no
N	923	923	951
R^2	0.2501	0.3475	0.2612

Table 10: **The impact of funding levels to adapt the MAP-21 bill**

This table displays results when estimating the following prediction model

$$update_{i,t} = \alpha + \theta^P \text{funding}^+_{i,t-1} + \theta^N \text{funding}^-_{i,t-1} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t}$$

where $update_{i,t}$ is a dummy variable equal to one in case the plan adopted the MAP-21 legislation in 2012, $funding^+_{i,t-1}$ ($funding^+_{i,t-1}$) is the positive (negative) component of the plan's funding status, X is a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share invested in risky assets) and γ_k is either an industry-fixed effect. Details on sample selection criteria are in Appendix Table 5, detailed variable definitions are in Appendix Table 6. Sample of 5,405 U.S. single employer defined benefit pension plans, 2012.

	Logit	
	(1)	(2)
$\text{funding}^+_{i,t-1}$	-2.7220***	-2.3143***
$\text{funding}^+_{i,t-1}$	3.2821***	3.8820***
$\text{size}_{i,t}$		0.2345***
$\text{duration}_{i,t}$		0.5618*
$\text{risky}_{i,t}$		0.5684***
industry dummies	no	yes
N	5218	5218
$PseudoR^2$	0.06	0.11

Appendix Table 1: Sample selection procedure, Form 5500, 1999-2007

	Number of Observations	
	Plan-years	Plans
Form 5500: DB Pension Plans	**101747**	**19511**
Additional sample restrictions		
- non single-employer plans	-15734	-2332
- plans with < 100 participants	-1385	-498
- missing & erroneous information assets and liabilities[a]	-2927	-731
- missing & erroneous information on interest rate[b]	-362	-19
- missing & erroneous information on mortality tables[c]	-30532	-3545
- missing & erroneous information on asset allocation[d]	-1927	-423
= Final Sample	**48880**	**11963**

[a] We drop observations with missing, zero or negative values for current pension liabilities (eliminates 2,290 obs.), in case plans employ more than one actuarial liability method (eliminates 487 obs.), if information on actuarial liabilities is missing, zero or negative (eliminates 7 obs.) and if values for pension assets are missing, zero or negative (eliminates 143 obs.)

[b] We drop observations with missing values for either the current or the accrued pension liability discount rate (eliminates 362 obs.)

[c] We drop observations in case information on mortality tables for male workers are missing (eliminates 133 obs.), in case different mortality tables are used for pre- and post-retirement (eliminates 3,755 obs.), if the mortality tables is specified as "Other" (eliminates 18,406 obs.), in case no mortality tables is specified (eliminates 9 obs.), if a hybrid version of a mortality tables is specified (eliminates 7,452 obs.), if information on the retirement age is missing or the retirement age specified is less (greater) than 56 (65) years (eliminates 777 obs.)

[d] We eliminate observations in case individual pension investments, specified in Schedule H of the Form 5500, are negative (eliminates 643 obs.) or are missing (eliminates 1,284 obs.)

Appendix Table 2: Variable Definitions, 1999 - 2007

Variable	Description
I: Form 5550, Main Section (General Information)	
participants (all)	TOT_PARTCP_BOY_CNT
participants (retired)	RTD_SEP_PARTCP_RCVG_CNT + BENEF_RCVG_BNFT_CNT
industry	BUSINESS_CODE
II: Form 5500, Schedule B (Actuarial Information)	
current liability (CL)	ACTRL_RPA94_INFO_CURR_LIAB_AMT
accrued liability (AL)	max[ACTRL_ACCR_LIAB_GAIN_MTHD_AMT, ACTRL_ACCR_LIAB_AGE_MTHD_AMT]
pension assets (PA)	ACTRL_CURR_VALUE_AST_01_AMT
CL interest rate (r^{CL})	ACTRL_CURR_LIAB_RPA_PRCNT
AL interest rate (r^{AL})	ACTRL_VALUATION_INT_PRE_PRCNT
mortality table	ACTRL_MORTALITY_MALE_PRE_CODE
retirement age	ACTRL_WEIGHTED_RTM_AGE
III: Form 5500, Schedule H (Financial Information)	
cash	NON_INT_BEAR_CASH_EOY_AMT + INT_BEAR_CASH_EOY_AMT
accounts receivable (AR)	EMPLR_CONTRIB_EOY_AMT + PARTCP_CONTRIB_EOY_AMT + OTHER_RECEIVABLE_EOY_AMT
US treasuries (rf)	GOVG_SEC_EOY_AMT
corporate debt (rd)	CORP_DEBT_PREFERRED_EOY_AMT + CORP_DEBT_OTHER_EOY_AMT
equities	PREF_STOCK_EOY_AMT + COMMON_STOCK_EOY_AMT
joint ventures	JOINT_VENTURE_EOY_AMT
real estate	REAL_ESTATE_EOY_AMT
loans	OTHER_LOANS_EOY_AMT + PARTCP_LOANS_EOY_AMT
trusts	INT_COMMON_TR_EOY_AMT + INT_POOL_SEP_ACCT_EOY_AMT + INT_MASTER_TR_EOY_AMT
funds	INT_103_12_INVST_EOY_AMT + INT_REG_INVST_CO_EOY_AMT
insurance	INS_CO_GEN_ACCT_EOY_AMT
other	OTH_INVST_EOY_AMT
employer	EMPLR_SEC_EOY_AMT + EMPLR_PROP_EOY_AMT
buildings	BLDGS_USED_EOY_AMT
total investment	cash + AR + rf +rd + equities + JV + RE + loans + trusts + funds + insurance + other + employer + buildings
IV: Computed plan-specific variables[b]	
B	(CL - AL)/AL
funding	(CA - CL)/CL
r^{Δ}	r^{CL} - r^{AL}
death rate (q)	taken from respective mortality table[a]
t-period survival rate (${}_tp_x$)	$\Pi_{i=0}^{t-1}(1-q_{x+i})$
life expectancy (LE)	$\sum_{t=1}^{\infty} {}_tp_x$
LE^{Δ}	$LE^{CL} - LE^{AL}$
size	log(PA)
duration	retired/all
risky	1 - (cash - AR - rf - rd)/(total investment)
V: Computed firm-specific variables (based partly on Compustat mnemonics[C])	
rel. size[d]	CL_j/at
leverage	$(CL_j + dlc + dltt)/(CA_j + prcc\_f \times csho + dlc + dltt)$
Z-score[e]	$1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + X_5$
Q	$(prcc\_f \times csho + dlc + dltt - invt)/at$
dividend	$(dvc + dvp)/(prcc\_f \times csho)$

[a] Over the sample period, mortality tables employed by pension plans include (1) the 1951 Group Annuity Table, (2) the 1971 Group Annuity Table, (3) the 1971 Individual Annuity Mortality, (4) the Unisex Pensioner 1984 Table, (5) the 1983 Individual Annuity Table, (6) the 1983 Group Annuity Table, (7) the 1983 Group Annuity Table (Rev. Rule 95-28), (8) the Uninsured Pensioner Table 1994 and (9) the 2007 Mortality Table for 1.412(I)(7)-1 of the Income Tax Regulation.

[b] The plan-specific variables B, funding, r^{Δ}, size and duration are winsorized at the 0.5 (99.5) percent level.

[c] The sponsor-specific variables B, funding, r^{Δ}, size, duration, relative size, leverage, all components of the Z-score, Q and dividend payments are winsorized at the 0.5 (99.5) percent level.

[d] Aggregate firm specific variables (generically called W_j) that are based on pension plan data are computed as follows $W_j = \sum_{i=1}^{N} w_i$ where N is the number of pension plans per plan sponsor in a given year. Average firm specific variables (generically called U_j) that are based on pension plan data are computed as value weighted averages using the weights (generically called $u_{j,i}$)of each pension plan relative to plan sponsor (where $u_{j,i} = CL_i/CL_j$).

[e] Using Compustat mnemonics, X_1 is $(act - lct)/at$, X_2 is re/at, X_3 is $oiadp/at$, X_4 is $(prcc\_f \times csho)/(dlc + dltt)$ and X_5 is $sale/at$.

Appendix Table 3: The impact of the lagged funding status on pension liabilities

This table displays results when estimating the partial effect of the lagged funding status on the bias variable $B_{i,t}$, which is defined as the relative difference between current pension liabilities (CL) and accrued pension liabilities (AL). The regression is given by

$$B_{i,t} = \alpha + \theta \text{funding}_{i,t-1} + \beta_1 r^{\Delta}_{i,t} + \beta_2 LE^{\Delta}_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t}$$

where funding is measured as the difference between the current value of pension assets and the current value of pension liabilities (relative to the current value of pension liabilities), $r^{\Delta}_{i,t}$ denotes the difference in discount rate assumptions ($r^{\Delta}_{i,t} = r^{CL}_{i,t} - r^{AL}_{i,t}$), $LE^{\Delta}_{i,t}$ the difference in life expectancy assumptions ($LE^{\Delta}_{i,t} = LE^{CL}_{i,t} - LE^{AL}_{i,t}$), $X_{i,t}$ is a vector of additional control variables (size of pension plan, a proxy for the duration of pension liabilities and the share invested in risky assets), γ_k is either an industry-fixed or a plan-fixed effect (in which case $k = i$) and η_t are time-fixed effects. In column (4), the funding status is split into a positive (overfunded) and negative (underfunded) component (which records negative funding levels with a positive sign). The estimation is done using both OLS-estimation (Panel A) and by accounting for plan-fixed effects (Panel B). Standard errors are adjusted for heteroskedasticity. Details on sample selection criteria are in Appendix Table 1, detailed variable definitions are in Appendix Table 2. Sample of 11,963 U.S. single employer defined benefit pension plans and 48,880 plan-years, 1999-2007.

Control Variables	(1)	(2)	(3)	(4)
Panel A: OLS Estimation				
$\text{funding}_{i,t-1}$	-0.1370***	-0.1332***	-0.1275***	
$r^{\Delta}_{i,t}$	-0.0014***	-0.0014***	-0.0014***	-0.0013***
$LE^{\Delta}_{i,t}$	0.0332***	0.0321***	0.0265***	0.0250***
$\text{size}_{i,t}$		-0.0066***	-0.0039***	-0.0019**
$\text{duration}_{i,t}$		0.2208***	0.1810***	0.1736***
$\text{risky}_{i,t}$		0.0296***	0.0182***	0.0211***
$\text{funding}^{+}_{i,t-1}$				-0.0745***
$\text{funding}^{-}_{i,t-1}$				0.3234***
time dummies	yes	yes	yes	yes
industry dummies	yes	yes	yes	yes
N	33730	33730	33730	33730
R^2	0.3396	0.3739	0.4068	0.418
Panel B: Fixed Effect Estimation				
$\text{funding}_{i,t-1}$	-0.0591***	-0.0565***	-0.0305***	
$r^{\Delta}_{i,t}$	-0.0015***	-0.0014***	-0.0014***	-0.0014***
$LE^{\Delta}_{i,t}$	0.0301***	0.0295***	0.0191***	0.0191***
$\text{size}_{i,t}$		0.0330***	-0.0018	-0.0018
$\text{duration}_{i,t}$		0.0914***	0.0175	0.0173
$\text{risky}_{i,t}$		0.0004	0.0016	0.0016
$\text{funding}^{+}_{i,t-1}$				-0.0293***
$\text{funding}^{-}_{i,t-1}$				0.0342***
time dummies	yes	yes	yes	yes
industry dummies	no	no	no	no
N	33730	33730	33730	33730
R^2	0.402	0.4108	0.4367	0.4367

Appendix Table 4: Sample selection procedure, Compustat, 1999-2007

	Number of Observations	
	Firm-years	Firms
Compustat	**110686**	**15284**
Additional sample restrictions		
- missing EIN	-17108	-2378
- change reporting date	-2147	-69
= Merged Compustat/Form5500 Sample	**6401**	**952**
- financial firms or utilities	-1125	-242
- more than one observation per year	-2223	0
= Intermediate Sample (Table 4)	**3053**	**710**
- missing information on financial variables	-256	-40
= Final Sample	**2797**	**670**

[a] We drop observations in case either the EIN or a firm's gvkey appears twice in a fiscal year

[b] We drop observations financial firms (eliminates 692 obs.) or utilities (eliminates 433 obs.)

[c] We drop observations with missing values of book assets (eliminates 2 obs.), market value of the firm (eliminates 3 observations), dividend payments (eliminates 5 observations) and Tobin's q (eliminates 6 obs.) In addition, we drop observation in case there are missing values for Altman's z-score (eliminates 240 obs.)

Appendix Table 5: Sample selection procedure, Form 5500, 2011-2012

	Number of Observations	
	Plan-years	Plans
Form 5500: DB Pension Plans	**22729**	**13754**
Additional sample restrictions		
- non single-employer plans	-407	-229
- plans with < 100 participants	-8206	-5244
- missing & erroneous information assets and liabilities[a]	-32	-14
- missing & erroneous information on contributions[b]	-444	-161
- missing & erroneous information on asset allocation[c]	-533	-296
- missing & erroneous information in interest rates	-128	-60
- missing & erroneous information in 2011[d]	-419	-408
= Intermediate Sample	12560	7342
- observations in 2011	-7342	-2124
= Final Sample in 2012	**5218**	**5218**

[a] We drop observations with missing, zero or negative values for pension liabilities (eliminates 27 obs.) and if values for pension assets are missing, zero or negative (eliminates 5 obs.)

[b] We drop observations with missing values for mandatory pension contributions (eliminates 159 obs.) and if values for pension contributions are missing (eliminates 285 obs.)

[c] We eliminate observations in case individual pension investments, specified in Schedule H of the Form 5500, are negative (eliminates 137 obs.) or are missing (eliminates 396 obs.)

[d] Plan sponsors are allowed to use interest rates that precede or follow the true valuation date. For example, if the employed interest rates precede (follow) the valuation date by 5 months it is said that the plan uses a look back (forward) period of 5 months. Because the number of look back (forward) months is not stated, we identify the number of look back (forward) months employed by the pension plan by comparing the stated segment interest rates in the Form 5500 to the officially published segment interest rates over a 24 months interval ($+/-$ 12 months) around valuation date. Once the difference between these rates is sufficiently close to zero (we use $+/-$ 2 basis points to allow for typos), this identifies the appropriate number of look back (forward) months to be used in 2012. Observations for which we are unable to identify the appropriate number of look back (forward) rates are dropped.

Appendix Table 6: Variable Definitions, 2011-2012

Variable	Description
I: Form 5550, Main Section (General Information)	
participants (all)	tot_partcp_boy_cnt
participants (retired)	rtd_sep_partcp_rcvg_cnt + benef_rcvg_bnft_cnt
industry	business_code
II: Form 5500, Schedule B (Actuarial Information)	
liability	sb_tot_fndng_tgt_amt
assets	sb_curr_value_ast_01_amt
contributions (mandatory)	sb_fndng_rqmt_tot_amt
contributions	sb_contr_alloc_curr_yr_02_amt
yield curve	sb_yield_curve_ind
interest	sb_eff_int_rate_prcnt
interest (segment t)a	interest_segt
interest (segment 2)	interest_seg2
interest (segment 3)	interest_seg3
III: Form 5500, Schedule H (Financial Information)	
cash	non_int_bear_cash_eoy_amt + int_bear_cash_eoy_amt
accounts receivable (AR)	emplr_contrib_eoy_amt + partcp_contrib_eoy_amt + other_receivables_eoy_amt
US treasuries (rf)	govt_sec_eoy_amt
corporate debt (rd)	corp_debt_preferred_eoy_amt + corp_debt_other_eoy_amt
equities	pref_stock_eoy_amt + common_stock_eoy_amt
joint ventures	joint_venture_eoy_amt
real estate	real_estate_eoy_amt
loans	other_loans_eoy_amt + partcp_loans_eoy_amt
trusts	int_common_tr_eoy_amt + int_pool_sep_acct_eoy_amt + int_master_tr_eoy_amt
funds	int_103_12_invst_eoy_amt + int_reg_invst_co_eoy_amt
insurance	ins_co_gen_acct_eoy_amt
other	oth_invst_eoy_amt
employer	emplr_sec_eoy_amt + emplr_prop_eoy_amt
buildings	bldgs_used_eoy_amt
all	cash + AR + rf +rd + equities + JV + RE + loans + trusts + funds + insurance + other + employer + buildings
IV: Computed plan-specific variables[b]	
funding	(assets - liability)/liability
Δ interest (segment t)	interest (segment t) - published segment interest rate[c]
Δ interest	$\sum_{t=1}^{3}$ Δ interest (segment t)
update	1 if Δ interest $>$ -2 bp & Δ interest $<$ 2bp
size	log(PA)
duration	retired/all
risky	1 - (cash - AR - rf - rd)/all

[a] The segmented yield curve concept distinguishes between three different segment rates, implying that i = (1, 2, or 3).

[b] The plan-specific variables funding, r^{Δ}, size and duration are winsorized at the 0.5 (99.5) percent level.

[c] The published segment interest rate is taken from the Internal Revenue Service and is applied over a 24 months interval around the valuation date. See Appendix Table 5 for more details.