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Do Pension Plans Strategically Use Regulatory Freedom?

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Do pension plans strategically use regulatory freedom?*

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Abstract

We use a historical experiment to test whether U.S. corporate defined benefit pension plans strategically use regulatory freedom to lower the reported value of pension liabilities, and hence required cash contributions. For some years, pension plans were required to estimate two liabilities - one with mandated discount rates and mortality assumptions, and another where these could be chosen freely. Using a sample of 11,963 plans, we find that the regulated liability exceeds the unregulated measure by 10 percent and the difference further increases for underfunded pension plans. Moreover, underfunded plans tend to assume lower life expectancy and substantially higher discount rates. The effect persists both in the cross-section of plans and over time and it serves to reduce cash contributions. Finally, we show that credit risk is unlikely to explain the finding. Instead, it seems that plans use regulatory leeway as a simple cash management tool.

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1 Introduction

The Employee Retirement Income Security Act of 1974 (ERISA) established minimum sponsor contribution standards for private industry defined benefit (DB) pension plans. Despite subsequent rounds of legislation aimed at further ensuring adequate plan funding, plan sponsors still kept considerable leeway in calculating contributions. Presumably to expedite passage through Congress, it contains provisions that allow DB pension plan sponsors to use less stringent actuarial assumptions and thereby reduce funding gaps and required sponsor contributions.

Giving more freedom to plan sponsors involves a difficult trade-off. While a temporary funding relief for underfunded pension plans provides breathing room that might restore the long-term viability of plan sponsors, it may undermine the interests of their employees and retirees. By allowing for lower pension contributions, both credit risk and longevity risk (the risk of retirees outliving their financial resources) is shifted from shareholders to pension plan participants and ultimately to the Pension Benefit Guaranty Corporation (PBGC) and the taxpayer. For well funded and financially healthy pension plans, this risk may be negligible. However, it may become more relevant if underfunded pension plans are more likely to opt for such a temporary funding relief.

The objective of this paper is to investigate whether U.S. corporate DB pension plans strategically use regulatory freedom to their own benefit. We tackle this question by exploiting historical particularities of pension funding law, which we detail below. Regulation surrounding pension funding law is preoccupied with the level of plan funding and required cash contributions and, as such, our results complement the findings by Bergstresser et al. (2006) who document manipulation of pension expenses in audited financial statements.

We focus on a large sample of pension plans provided by the U.S. Department of Labor (DOL), which contains detailed information on various actuarial assumptions, including the mortality tables and/or discount rates used to estimate pension plan 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. In addition, we provide a further robustness check of the MAP-21 episode in 2012 focusing on another sample of 5,452 plans.

During the 1999 to 2007 period, the Internal Revenue Service (IRS) required plan sponsors to employ two different liability concepts for calculating required sponsor contributions: a current and an accrued liability measure.[1] 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 (commonly referred to as the normal cost) and the minimum funding contribution which additionally amortizes the amount of any underfunding into the current year required contribution. The current liability measure was the basis for additional top-up contributions for significantly underfunded plans.

This historical experiment allows us to investigate the difference between the two liability concepts, which is both interesting and useful. First, we are able to simply describe whether and by how much the two liability measures differ. Second, because we also have data on the underlying discount rate and mortality assumptions, we are able to investigate why the two measures differ and, more importantly, explore the difference in the underlying actuarial assumptions. Finally, because the analysis focuses on comparing two different measures (liabilities or actuarial assumptions) from the same pension plan at the same point in time, we are able to control for many plan specific factors that otherwise would be unobservable.

We find that, on average, accrued pension liabilities would have to be increased by 10 percent in order to keep up with the regulated current liability measure. Most of the difference stems from using higher discount rates. Unsurprisingly, when given the choice, sponsors often use a higher rate than the one mandated for the current liability estimation. 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 subset of

[1] Pension liabilities are calculated in several ways, depending on the purpose: funding, accounting or settlement. In this paper we focus on funding. The current liability corresponds to the accumulated benefit obligation (accounting) and termination liability (settlement), and the accrued liability to the projected benefit obligation (accounting).

pension plans made substantially lower and outdated life expectancy assumptions.

More importantly, our analysis reveals that the funding status of a pension plan has a strong impact on actuarial assumptions. Underfunded plans are more likely to assume lower life expectancy (relative to the regulated mortality table) and they employ substantially higher discount rates (relative to the mandated rate). Moreover, we document a similar time-series effect as changes in funding levels are negatively correlated with changes in relative discount rates. Taken together, underfunded plans seem to stretch actuarial assumptions in order to reduce the report value of pension liabilities.

Crucially, this appears contrary to the regulations under which actuarial assumptions should not be related to the funding status of the pension plan. In blunt words, life expectancy and discount rate assumptions are not supposed to relate to the plan's funding status. The results suggest a degree of opportunistic behavior of pension plans, as the lower reported value of pension liabilities translates into a substantial reduction in cash contributions. Specifically, we find that a 10 basis point increase in discount rates (relative to the mandated rate) reduces the ratio of normal cost to pension assets by up to 7 basis points, while a one year decrease in life expectancy assumptions triggers a reduction of 37 basis points. To put these numbers into perspective, such moderately tweaked actuarial assumptions would reduce cash contributions for underfunded pension plans by up to twenty percent.

We then explore an alternative explanation for the negative relation between discount rates and funding levels. Specifically, we use firm level data from Compustat to test the extent to which credit risk of the plan sponsor "explains" the use of higher discount rates. While economically reasonable, it is important to note that such an implicit discount rate adjustment is not intended by law. This is because the actuarial liability is not supposed to measure the market value of the pension promise to the plan participant.[2] To address this issue, we employ a two-stage regression framework. In the first step, we estimate the implied deviation from the regulated discount rate based on plan specific information as well as various firm characteristics controlling for the

[2]Instead, it is a regulated actuarial funding target concept that should not reflect the credit risk of the plan sponsor. We discuss this issue in detail in Section 4.2.2.

sponsor's credit risk. We then take the residual from the first stage regression (i.e. the part of the deviation that is left unexplained by credit risk and other plan controls) and regress it on the funding level of the plan sponsor. The results continue to suggest that underfunded plans employ substantially higher discount rates. Moreover, we show that this result robustly holds even among plan sponsors with low measures of credit risk. These findings suggest that plans strategically use regulatory leeway and manage actuarial assumptions as a cash management tool that seems to smooth cash contributions to the pension plan. This "tool" is used independently of the credit risk of the plan sponsor.

The Pension Protection Act (PPA) of 2006 stopped the dual use of the two competing liability definitions and required that, as of 2008, firms only employ one regulated liability measure. However, our results continue to be highly relevant. To illustrate, we relate our findings to the recently introduced MAP-21 bill, which provided relief to DB pension plan sponsors by allowing the use of historical discount rates (which are higher than current rates) when computing pension liabilities. Focusing on 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.

The findings in this paper contribute to a literature linking corporate finance and pension plan management. For instance, firms take into account the impact of mandatory pension contributions when setting investment policy (Rauh, 2006; Bakke and Whited, 2012), they trade-off tax savings from interest payments and pension contributions with overall bankruptcy costs (Shivdasani and Stefanescu, 2010), they consider the overall consolidated leverage when estimating the cost of equity (Jin, Merton, and Bodie, 2006) and insurance premia to the PBGC also reflect whether a plan is underfunded (Brown, 2008). As a consequence, management of corporate DB pension plans may have an incentive to manipulate the reported values of pension liabilities and pension assets in case this reduces funding requirements, decreases consolidated leverage ratios or increases short-term profits.[3]

Several papers have investigated whether pension management is distorted by agency problems. For example, Ashtana (1999) uses pension funding data to investigate determinants of actuarial choices for U.S. corporate DB pension plans. The paper shows that overfunded pension plans make more conservative actuarial choices. For instance, they employ lower discount rates, more conservative actuarial cost methods and assume higher rates of future salary growth when computing expected benefit payments.[4] 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. Such higher return on asset assumptions reduce pension expenses, increase earnings and thereby generate value for management if compensation is tied to short-term accounting based performance measures.[5]

Focusing on public pension plans, Brown and Wilcox (2009) and Novy-Marx and Rauh (2011) provide evidence that U.S. pension funds discount future pension liabilities using incorrect (but not unlawful) 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

[3]In practice, management of corporate DB pension plans needs to compute and report values for pension assets and liabilities following two different sets of rules. Pension funding rules are governed by law described in the Internal Revenue Code (IRC) and deal with cash contributions to the pension plan. Pension accounting rules are set by the Financial Accounting Standards Board (FASB) and are used to determine pension expenses, see Pension Committee of the American Academy of Actuaries (2004) for a detailed explanation of the differences between the two concepts. Actuarial assumptions underlying the two concepts typically differ (Bodie et al., 1987).

[4]Early work employing small samples of pension plans also suggest a negative (positive) relation between funding (profitability) and discount rate assumptions, see for example Feldstein and Morck (1983) and Bodie et al. (1987).

[5]Bartram (2015) provides complementary recent evidence showing that financially distressed plan sponsors and/or sponsors of underfunded plans make more aggressive return on asset assumptions, which in turn help to decrease pension expenses.

decreased and populations have aged over this period.

This paper contributes to the literature by providing novel evidence on the liability management of U.S. corporate DB pension plans. We show 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 the documented opportunistic behaviour relating to pension expenses and earnings management (Bergstresser et al., 2006), and we also show that attempts to take advantage of the leeway to set discount rates are not only prevalent among public U.S. pension funds (Brown and Wilcox, 2009; Novy-Marx and Rauh, 2011). In fact, and to the best of our knowledge, we are the first to provide large sample evidence investigating the relation between funding levels, actuarial assumptions and pension liabilities.[6]

Second, our novel research design exploits the difference between regulated and unregulated pension liabilities or actuarial assumptions. This measure contributes to the literature as it benchmarks a plan-specific actuarial assumption relative to its regulated counterpart and thereby helps to interpret whether an assumption is unusually high or low. Moreover, it allows us to control for many unobservable plan- and time-specific factors. As a consequence, we are the first to provide evidence showing that the funding status also distorts life expectancy assumptions.

Third, we show that stretching actuarial assumptions directly benefits the pension plan as cash contributions are reduced. The finding contributes to the literature both by directly illustrating how pension plans could opportunistically mitigate the impact of mandatory cash contributions and by indirectly relating our findings to a literature that investigates the impact of cash contributions to corporate financial decisions (Rauh, 2006; Bakke and Whited, 2012). Moreover, we show that the negative relation between discount rates and funding levels is unlikely to be explained by the credit risk of the plan sponsor.

Finally, our results are highly policy relevant as we document that pension plans strategically

[6] Our main analysis covers 11,963 pension plans (48,880 plan-years) over the period from 1999 to 2007. Feldstein and Morck (1983) investigate 132 plans in 1979, Bodie et al. (1987) cover 515 plans in 1980 and Ashtana (1999) analyses 2,419 plans over the period 1990 to 1992. The analysis in Bartram (2015) covers approximately 5,000 observations on U.S. pension plans – however, contrary to our paper, his analysis focuses on pension accounting (not pension funding) and he finds a positive relation between funding and discount rates.

employ regulatory leeway to their own benefit. Because pension plan participants and retirees do not take part in setting actuarial assumptions, our findings raise the possibility of a wealth transfer from retirees and workers to shareholders.

The paper proceeds as follows. Section (2) describes the basics of pension funding law, Section (3) presents the data, Section (4) introduces the historical experiment and Section (5) discusses policy implications in light of the MAP-21 bill. Section (6) concludes.

2 A primer on pension funding law

Up until 2008, U.S. pension funding law required sponsors to estimate two different concepts of pension liabilities for purposes of calculating required sponsor contributions (Pension Committee of the American Academy of Actuaries, 2004; Munnell and Soto, 2007). When computing the normal costs or the minimum funding contribution (MFC), 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 ERISA in 1974, plan sponsors 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.[7]

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. The CL was used to calculate a special deficit reduction contribution (DRC) for significantly underfunded plans following the Omnibus Budget Reconciliation Act of 1987 (OBRA 1987). Unlike for the AL calculation, the mortality

[7] 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...".

table and discount rate assumptions for the CL calculation were prescribed by legislation and the IRS. For example, the Retirement Protection Act of 1994 (RPA 1994) mandated the use of the GAM-83 mortality table in determining current liability and it also required the Treasury to review the mortality tables every five years and update them as necessary to reflect changes and trends in pension plan experience.[8] The 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 constant-maturity Treasury bond yields, but then changed the requirement for plan years beginning in 2004 to a weighted average of long-term investment grade corporate bond yields.

The passage of the PPA 2006 removed some of the wiggle room in setting actuarial assumptions starting in 2008. Since then the Treasury prescribes by regulation both the interest rate and the mortality table to be used for all liability determinations. For mortality tables, the 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 Congress provided pension contribution relief by signing into law the MAP-21 Act. 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.[9] Because historical corporate bond yields, especially the

[8]Small plans (those with fewer than 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 liability calculations.

[9]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

yields in the late 80s and early 90s, were significantly higher than current yields, this adjustment increases current discount rates, which 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 Sample characteristics

3.1 Description of pension liabilities

This study uses the Form 5500 pension plan data filed with the U.S. Department of Labor (DOL).[10] 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.[11] 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. The average plan is included in the sample for four years (median also equals 4) and, on average, 5,959 plans are included in the

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.

[10] We use data provided by the Centre of Retirement Research at Boston College.

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

sample each year. All variables used below are exactly defined in Appendix Table 2.

Table 1 presents summary statistics for the main variables used in this paper. Columns (2) and (3) compare 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. Plan assets, on the other hand, exceed current liabilities substantially in the early years of the sample which is consistent with previous findings (Rauh, 2009), but average funding levels decrease at the beginning of the millenium.

Column (4) displays the percentage difference between current and accrued liabilities for each pension plan at each point in time. We refer to this difference as the liability gap measure $G_{i,t}$,

$$G_{i,t} = \frac{CL_{i,t} - AL_{i,t}}{AL_{i,t}} \qquad (1)$$

where CL (AL) denotes current (accrued) pension liabilities and $G_{i,t}$ is the percentage difference between them. A value of $G_{i,t}$ exceeding zero implies that accrued pension liabilities would increase by G percentage points if more conservative actuarial assumptions were employed. Put differently, in such a case reported pension liabilities are low relative to the regulated pension liability concept. The table shows that accrued liabilities would need to be increased by 10 percent (median 11 percent) in order to keep up with the regulated current liability measure. Figure 1 further displays the distribution of this gap measure for our sample and shows that in 71 percent of the cases, current liabilities exceed the accrued liability measure.

Theoretically, the two measures do not need to be equal. For example, as explained in Section 2, accrued liabilities should account for future expected salary increases which - ceteris paribus - would result in a higher value than under the current liability concept. The empirically observed lower (average) values of AL suggest that plan sponsors deviate in other assumptions which mitigate this effect. From a regulatory perspective, it would be worrying if such other assumptions were correlated with the funding status of the pension plan.

As a univariate preview of subsequent results, Figure 2 displays the non-parametric relation between the funding status (F) of a pension plan and the pension liability gap measure (G), which is also measured in percentage points (pp).

$$F_{i,t} = \frac{PA_{i,t} - CL_{i,t}}{CL_{i,t}} \tag{2}$$

where PA is the current market value of plan assets. A funding status of zero implies that pension assets match pension liabilities and that the plan is fully funded. The figure suggests that the level of plan funding is negatively correlated with the liability gap measure.[12] For example, for plans that are underfunded by 25 percent the gap between accrued and current liabilities is about 18 percent, whereas accrued and current liabilities are virtually identical 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 proceed, we first describe two important actuarial assumptions that underly the two liability measures. We then investigate whether the funding status has a direct impact on them.

3.2 Description of actuarial assumptions

The difference between current and accrued pension liabilities should to a large degree be explained by the main actuarial assumptions underlying the computation. The Form 5500 database contains detailed information on two of the main assumptions: discount rates and mortality tables.

Under the current liability measure, discount rates are regulated and were either based on yields of long-term government bonds or high-quality corporate bonds. Accrued liabilities, on the other hand, could be computed using the expected return on pension assets as a discount rate.[13] We quantify the magnitude of different discount rate assumptions by computing an excess

[12] Note that the funding status exceeds 0.65 in only 3.6 percent of all cases, thereby suggesting that the right tail of Figure 2 happens rarely.

[13] See page 26 line 6(e) in IRS (2007). Under ERISA, this assumption should be selected "on the basis of actuarial assumptions and methods, which, in the aggregate, are reasonable (taking into account the experience of the plan

discount rate ($r_{i,t}^{\Delta}$), defined as the difference between the freely chosen discount rate ($r_{i,t}^{AL}$) and the government imposed rate ($r_{i,t}^{CL}$):

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

Another source of potential differences are life expectancy assumptions. We first compute life expectancy under the state imposed GAM-83 mortality table (relevant for CL) and then compare it to the life expectancy under the mortality table chosen by the plan sponsor for the accrued liability measure.[14] Because mortality tables only contain information on expected death rates at a given age, we convert them into life expectancy assumptions by computing and summing up all successive multi-period survival rates (Coughlan et al., 2007). We then define a corresponding excess life expectancy assumption ($LE_{i,t}^{\Delta}$) by computing the difference between life expectancy under the accrued pension liability measure ($LE_{i,t}^{AL}$) and the current liability measure ($LE_{i,t}^{CL}$) at the average retirement age:

$$LE_{i,t}^{\Delta} = LE_{i,t}^{AL} - LE_{i,t}^{CL} \tag{4}$$

Figure 3 illustrates the overall distribution of individual actuarial assumptions. Panel A contains a frequency plot of excess discount rate assumptions (i.e. the variable $r_{i,t}^{\Delta}$ introduced in equation 3). 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 excess life expectancy assumptions (i.e. the variable $LE_{i,t}^{\Delta}$ introduced in equation 4). Here, the picture is different. Most plans employ the 1983 GAM mortality table, implying that the average difference in life expectancy assumptions is likely to be small. However, the graph also illustrates that there are a few cases where pension plans employ significantly lower life expectancy

and reasonable expectations), and which, in combination, offer the actuary's best estimate of anticipated experience under the plan", see page 871 of ERISA (1974).

[14]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.

assumptions.

The heterogeneity in actuarial assumptions does not only reflect differences across firms but also within-firms over time. Table 2 presents information on the corresponding changes in the underlying actuarial assumptions - Panel A shows summary statistics on changes in excess discount rates, whereas Panel B displays the corresponding information for changes in excess life expectancy assumptions. The table shows that most of the adjustment occurs by changing excess discount rate assumptions. For example, in 2005, 3,615 pension plans increased excess rates, 33 left them unchanged whereas 468 plans decreased rates, leading to an average increase in excess discount rates by 36 basis points.[15]

Knowledge of these two important actuarial assumptions proves useful to explain the observed variation in the pension liability gap measure, as shown by estimating the following reduced-form model

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

where X denotes a vector of additional control variables (to be introduced in the next paragraph), γ_k is either an industry-fixed or a plan-fixed effect (in which case $k = i$) and η_t are time-fixed effects.[16] Throughout the paper, standard errors under fixed effect estimation are computed according to Discroll and Kraay (1998) to account for possible cross-sectional and temporal interdependence among the error terms (Petersen, 2009). Equation 5 thus disentangles the effect of discount rate and life expectancy assumptions and further provides coefficient estimates for their partial impact.

The estimation of a linear reduced-form model requires that we control for additional factors that may also impact the difference between the two liability measures. For example, we control

[15] Note that the number of yearly increases, decreases and no-changes do not add up to the number of yearly observations because not all plans were also included in the sample in the previous year. In 2005, 847 plans were included for the first time (i.e. the difference between the total yearly observations and the number of increases, decreases and no-changes: 4963 - (3615 + 33 + 468) = 847.

[16] 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.

for plan size as smaller pension plans might not have the necessary degree of sophistication when choosing actuarial assumptions. Similarly, the duration of pension payouts might differ considerably from the one implied by using long-term yields under the current liability measure.[17] Finally, we control for the plan's investment into risky assets using the limited information that is provided on asset allocation in Schedule H of the Form 5500.[18] [19]

Table 3 provides estimates under OLS and plan-fixed effect estimation. Column (1) is based on OLS estimation and shows that interest and mortality assumptions alone explain 26 percent of the variation in the liability gap measure. Furthermore, the table implies that a 10 basis points increase in the discount rate differential increases the difference in pension liabilities by approximately 1.5 percentage points. Life expectancy assumptions also have an economically significant impact on pension liabilities: increasing excess life expectancy assumptions by an additional year decreases the difference between current and accrued liabilities by 3.2 percentage points. The coefficient estimates are robust to the inclusion of plan-specific control variables (size, duration and investment in risky assets), industry-, year- and firm-fixed effects.

4 Regulatory leeway and pension liability management

This section presents novel evidence showing that pension plans employ regulatory leeway when setting actuarial assumptions in a way that reduces the reported value of pension liabilities. Furthermore, we show that the opportunistic choice of actuarial assumptions directly reduces cash contributions to the pension plan. We conclude by investigating an alternative explanation for

[17] We define duration as one minus the ratio of retirees to all plan participants, see Appendix Table 2.

[18] However, note that the proxy based on the Form 5500 is rather crude: Schedule H includes preliminary information on the asset allocation of pension plans. The categorization distinguishes between cash and accounts receivables, fixed-income investments (e.g. Treasuries and corporate bonds), direct equity investments, real estate and indirect investments (e.g. trusts, funds, insurance investments). The control variable is defined as the fraction of assets that are not invested into cash, accounts receivables or fixed income investments, see Appendix Table 2.

[19] Rauh (2009) uses pension funding data and investigates whether risk shifting considerations drive asset allocation decisions of pension plans. His findings show that better funded plans or sponsors with high credit ratings invest a larger fraction of pension assets into equities, thereby suggesting that risk management motives may dominate agency conflicts for underfunded pension plans. However, consistent with existing economic theory (Sundaresan and Zapatero, 1997; Lucas and Zeldes, 2006; Benzoni et al., 2007), Rauh finds that the share of active plan participants is positively correlated with investment into risky securities.

the relation between funding and actuarial assumptions and therefore explore whether credit risk helps “explain” the choice of actuarial discount rates.

4.1 Do funding levels impact actuarial assumptions?

Having related actuarial assumptions to pension liabilities, we now investigate whether funding levels have a direct impact on those assumptions. This is a powerful exercise given that such an effect should not exist from a legal (or regulatory) perspective (Pension Committee of the American Academy of Actuaries, 2004; Munnell and Soto, 2007). We start by presenting evidence using pooled data before disentangling cross-sectional and time-series effects.

Pooled evidence

We first focus on mortality forecasting models as they clearly 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 employ such official mortality forecasts and they form the basis of corporate life expectancy assumptions.

Table 4 tests for the impact of funding levels on life expectancy assumptions by estimating the following logit model

$$y_{i,t} = \alpha + \theta F_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t} \tag{6}$$

where $y_{i,t}$ is a dummy variable equal to one in case the freely chosen life expectancy assumption is below the one mandated by the government (i.e. $LE^{\Delta}_{i,t} < 0$), $F_{i,t}$ is the funding status of plan i at time t (as defined in equation 2), the vector X includes the same set of control variables as used in the previous section, γ_k is an industry-fixed effect and η_t are time-fixed effects.

Table 4 displays corresponding results and shows that the funding status has a statistically and economically significant impact on life expectancy assumptions: a 10 percentage point increase in the funding status decreases the probability of using a less stringent mortality table by 5 to 8 percentage points. This effect is robust and pertains when the funding status is the only regressor (column 1) or equally when the full set of control variables, industry and time dummies are included (column 4).

Column 5 further splits the funding level into a positive and a negative component and tests whether the probability of using less stringent mortality tables responds asymmetrically to positive and negative funding levels. To ease interpretation of coefficients, negative funding levels are recorded with a positive sign (thus implying that a positive coefficient means that more underfunded plans have a higher corresponding probability). The coefficients on both variables are statistically significant and have the expected sign. We can see that most of the power comes from underfunded plans: a 10 percentage point increase in the level of underfunding increases the probability of using less conservative life expectancy assumptions by 12 percentage points.[20]

Regulation prescribed the use of the 1983-GAM mortality table for all sample years until (but excluding) 2007, when the more stringent 2007 mortality table was imposed. The new mortality table increases regulated life expectancy assumptions which - ceteris paribus - raises the likelihood of using less conservative life expectancy assumptions under the accrued liability measure. Put differently, unless plans also incorporate the more conservative (and up-to-date) life expectancy assumptions into the accrued liability measure, the probability of using an outdated mortality table increases in this year.

As an additional robustness check to including time dummies, Appendix Table 3 re-estimates the logit model and focuses only on the subsample from 1999 to 2006. For this period, the regulated life expectancy assumptions are constant implying that differences in excess life expectancy assumptions only relate to active decisions in pension liability management surrounding the accrued liability measure. Columns (1) to (5) show that results are quantitatively similar: a 10 percentage

[20] We have also estimated equation 6 using a dummy variable for being underfunded. This simpler model suggests that the probability of using less stringent mortality tables increases by 60 to 80% in case the plan is underfunded.

point increase in the level of underfunding raises the probability of using less conservative life expectancy assumptions by 11 percentage points.

Turning to actuarial discount rates, the law also does not give a role to financial risk measures but instead requires that the assumption should be reasonable. We first test whether funding levels affect differences in discount rate assumptions by estimating

$$r^{\Delta}_{i,t} = \alpha + \theta F_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t} \tag{7}$$

Table 5 displays corresponding results - irrespective of whether one employs OLS estimation (column 1) or accounts for plan-fixed effects (column 3), we find that the funding level has a strong negative impact on the choice of the excess discount rate. Moreover, when splitting funding into a positive and a negative component we find again 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 liability discount rates by approximately 13 basis points.

Variation in excess discount rates can arise due to changes in both actuarial and current liability discount rates. As a robustness check, we also test whether the funding status directly impacts actuarial discount rate assumptions only (i.e. the variable r^{AL}). Table 6 displays corresponding results and reinforces earlier findings. Funding levels have a strong negative impact on actuarial discount rate assumptions and the effect is again strongest for underfunded pension plans.

Comparing cross-sectional and time-series effects

Coefficient estimates obtained from a pooled regression analysis reflect both cross-sectional and time-series variation in the underlying variables (Wooldridge, 2006). From a practical perspective, it is interesting to know whether our results implicitly identify a set of plans that consistently exploit regulatory leeway in setting actuarial assumptions, or - whether more generally - any plan is more likely to cherry pick assumptions in case funding levels deteriorate. To answer this question, we perform both cross-sectional *Fama-MacBeth* regressions as well as traditional time-series analysis (Fama and MacBeth, 1973). Because life expectancy assumptions have been shown to be rather sticky (see Panel B in Figure 3), we focus this analysis on discount rate assumptions only.

Table 7 displays results of Fama-MacBeth regressions and reveals a strong cross-sectional relation between funding levels and discount rate assumptions. Focusing on the coefficient of funding in column (1), the impact is similar to the pooled regression analysis: a 10 percentage point increase in funding decreases excess discount rate assumptions by 5 basis points. Column (2) further shows that the effect is strongest for underfunded plans. Here, a 10 percentage point increase in the level of underfunding triggers a corresponding 12 basis points increase in excess discount rates. For completeness, the table also displays the cross-sectional sensitivity of actuarial discount rate assumptions to funding levels in columns (3) and (4). The results are quantitatively similar.

Table 8 presents results of an additional regression testing whether changes in funding lead to changes in discount rate assumptions. Specifically, columns (1) and (2) investigate the impact of changes in funding on changes in excess discount rate assumptions (i.e. changes in $r^{\Delta}_{i,t}$) and reveal a strong time-series effect that is consistent with the substantial amount of time-series variation that was documented in Table 2. The results complement the cross-sectional evidence and show that changes in funding levels are negatively correlated with changes in excess discount rate assumptions. The finding is again driven by underfunded pension plans: if underfunding gets worse, excess discount rates are reduced substantially.

Finally, columns (3) and (4) investigate changes in actuarial discount rates. The findings are interesting and warrant further explanation. Column (4) shows that increases in overfunding lead to increases in actuarial discount rate assumptions, whereas as no such effect is present in case underfunding deteriorates. The statistical explanation of the missing significance is due to the fact that changes in actuarial discount rates are not as frequent as changes in excess discount rate assumptions. In other words, most of the time series variability in excess discount rates (r^{Δ}) is driven by changes in the current liability discount rate (r^{CL}).

What is the practical implication of these findings? Cross-sectionally, there is ample evidence that more underfunded plans use higher discount rates. The results are robust and obtain for both the excess discount rate and the actuarial discount rate. In the time-series dimension, there is significant evidence that increases in plan underfunding are strongly correlated with decreases in excess discount rate assumptions. The fact that the same relation is missing for changes in actuarial discount rates suggests that plans *passively exploit* regulatory leeway over time.

In other words, the decrease in regulated discount rates that occurred during the sample period reflects to a large degree the reduction in risk-free rates. This reduction (in risk-free rates) should be equally relevant for the actuarial discount rate and therefore lead to an equivalent downward adjustment. However, most pension plans ignore this new information and opt to leave actuarial discount rates unchanged most of the time. The missing adjustment keeps accrued pension liabilities artificially low as interest rates do not reflect the new economic environment.

Robustness check

While terminating defined benefit pension plans is difficult and limited to bankruptcy proceedings, sponsors of pension plans have the option to restrict future participation in the plan by imposing so-called pension freezes (Rauh et al., 2013). In general, it is possible that the choice of actuarial assumptions for frozen pension plans might be driven by other considerations than for open ongoing plans.

For our sample of pension plans, freezes happen in approximately 6% of all observations. To test whether the behavior of frozen plans differs systematically from open plans, we exclude pension freezes from the sample and re-estimate our analysis. We find that the exclusion of frozen pension plans does not affect our quantitative and qualitative findings. Detailed results are available upon request.

4.2 Why do actuarial assumptions respond to funding levels?

The results above show that funding levels directly impact actuarial assumptions even though there is no legal role that would explain the relation. In this section, we discuss different potential explanations for the empirically observed relation.

4.2.1 Cash contributions and actuarial assumptions

Cash contributions of underfunded pensions plans are regulated by the IRS and are given by the maximum of two alternative computations: the minimum funding contribution or the deficit reduction contribution (Langbein and Wolk, 2000; Rauh, 2006; Bakke and Whited, 2012). The minimum funding contribution (MFC) is based on the unregulated accrued liability measure whereas the deficit reduction contribution (DRC) employs the regulated current liability measure (Pension Committee of the American Academy of Actuaries, 2004).

Consistent with Rauh (2006), we find that cash contributions are governed by the MFC for moderate levels of plan underfunding (e.g. plans that are underfunded by up to 25-30%).[21] The MFC reflects the normal cost, an amortization payment of the current funding shortfall, historical contributions and is given by

$$MFC_t = \text{normal\_cost}_t + \left(\frac{\text{AL - PA}}{n}\right)_t - FSA_{t-1} \tag{8}$$

where normal cost is the present value of newly accrued benefits, n is the period over which the actuarial funding shortfall ($AL - PA$) is amortized and FSA is the funding standard account.[22] Twisting actuarial assumptions thus directly translates into lower cash contributions to the pension fund, both by reducing normal cost (to be shown below) and by mitigating the effect of the additional amortization payments.

The normal cost reflects the present value of newly accrued benefits, which is computed using actuarial discount rates and life expectancy assumptions. To provide supporting evidence that stretching actuarial assumptions reduces the level of normal pension contributions, we estimate the following regression

$$\text{normal\_cost}_{i,t} = \alpha + \beta_1 r^{\Delta}_{i,t} + \beta_2 LE^{\Delta}_{i,t} + \beta_3 Part_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t} \tag{9}$$

where normal cost is measured in percentage points of pension assets and $Part$ is the number of

[21] See Figure 2 in Rauh (2006) for details.

[22] The FSA tracks the cumulative difference between actual historical and required contributions.

active plan participants (scaled again by the value of pension assets).

Table 9 displays corresponding results under OLS estimation (Panel A) and FE estimation (Panel B). Using the coefficient estimates of column (1) in Panel A, the table shows that a 100 basis points increase in excess discount rates (r^{Δ}) decreases normal costs by 70 basis points. Similarly, reducing excess life expectancy assumptions by a year triggers a reduction of 37 basis points. While adding further control variables reduces the effect of discount rate assumptions, they hardly impact the effect of life expectancy assumptions.

Actuarial assumptions do not only impact normal costs, but they also directly affect the reported value of accrued pension liabilities and thereby the amount of amortization payments due to underfunding. Based on the previous results displayed in Table 3, we can infer that a 100 basis points increase in discount rates would decrease liabilities by 15 percent whereas a one year increase in life expectancy would lead to a reduction of approximately 3 percent.

To put these numbers into perspective, Table 10 displays the potential cost savings from stretching actuarial assumptions for the average pension plan in our sample. Specifically, the table computes minimum funding contributions for a hypothetical pension plan with assets of $96 million, normal costs of 4.23 percent of the asset value and an amortization period of 10 years.[23] Columns (1) to (4) compute the minimum funding contribution under a base case scenario that varies the accrued value of pension liabilities from $96 million (no underfunding) to $120 million (20 percent actuarial underfunding). Column (4) shows that minimum funding contributions range from $4.2 million to $6.2 million, thereby suggesting that the amortization payment increases pension contributions by approximately 50 percent when plans are only 80 percent funded.

Columns (5) to (9) illustrate the impact of moderately twisting actuarial assumptions. Specifically, we assume that actuarial discount rates are increased by 10 basis points and life expectancy assumptions are reduced by one year. The two assumptions jointly decrease accrued liabilities by 4.5 percent and further reduce normal cost by 44 basis points. Illustrating the overall impact of those two effects, column (8) shows that the minimum funding contribution now ranges between

[23] The assumed amortization period of 10 years is consistent with Rauh (2006) and Bakke and Whited (2012).

\$3.6 million and \$5.5 million. Twisting actuarial assumptions thus can result in a significant reduction in cash contributions relative to the base case scenario – in fact, column (9) shows that the percentage reduction in the minimum funding contribution can be as high as 19 percent.

4.2.2 Is credit risk an alternative explanation?

Above findings suggest that a desire to reduce cash contributions to the pension fund may explain the relation between plan funding and actuarial discount rate assumptions. One related question is whether this observed behavior is related to the credit risk of the plan sponsor - are firms facing financial distress more likely to use favorable assumptions when calculating pension liabilities?

If this is the case, reported actuarial liabilities would be implicitly adjusted for the riskiness of the expected cash flows, which is contrary to regulation.[24] The actuarial liability measure has not been designed to measure the market value of promised pension benefits to plan participants, but instead it is a regulated funding target concept. In other words, the AL should not reflect credit risk because regulation aims to precisely avoid a mechanical reduction in pension contributions for underfunded plans (Pension Committee of the American Academy of Actuaries, 2004; Munnell and Soto, 2007).[25]

To test whether credit risk has any impact on actuarial assumptions, we 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

[24] Such an implicit channel would be conceptually different from the risk adjustment argument made by Brown and Wilcox (2009) and Novy-Marx and Rauh (2011). These papers investigate the value of public pension liabilities for the taxpayer and argue that future pension obligations should be valued at a rate that reflects the riskiness of the liabilities. Because public pension promises are typically protected by constitutional, statutory or common law guarantees, the corresponding discount rate should be (close to) the risk-free rate.

[25] From the perspective of a plan participant credit risk of the plan sponsor will still matter for his/her valuation of the pension promises. However, the complexities of such a valuation are typically large. First, DB pension plans are often set up as separate legal entities from the plan sponsor. From the perspective of a plan participant, only the underfunded component of accrued pension liabilities would be subject to the credit risk of the plan sponsor. Moreover, the risk is further reduced by the fact 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).

and results in a total of 6,401 matched observations (corresponding to 952 pension plans).[26] 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 all plans of a plan sponsor), allows us to further derive weighted-average values of life expectancy and discount rate assumptions. Keeping one observation per plan sponsor in a given year and requiring the availability of accounting information on a few selected variables (to be introduced below) reduces the total number of observations to 2,797 firm years (670 plan sponsors). Appendix Table 4 provides more details on the sample selection procedure.

Table 11 presents summary statistics on the main actuarial variables, this time measured at the level of the plan sponsor. Pension plan assets and liabilities are substantially larger than for the full sample of plans displayed in Table 1: accrued liabilities are equal to \$479 million and, on average, would need to be increased by 16 percent in order to keep up with the regulated current liability measure. As in the full sample, plan sponsors are well funded in the early years of the sample but then become underfunded in the years surrounding the burst of the dot-com bubble. Interestingly, the spread between actuarial and current liability discount rates is wider ($r^{\Delta} = 198bp$) whereas the difference in life expectancy assumptions is close to zero.

The aim of this section is to investigate whether credit risk explains the impact of funding levels on the difference in discount rate assumptions. We address the issue employing a two-stage regression approach. In the first stage, we estimate the implied deviation of accrued liability discount rates from the current liability measure (i.e. the fitted variable $\hat{r}^{\Delta}$) using the entire set of previously introduced control variables as well as proxies for the plan sponsor's credit risk and firm characteristics

$$r^{\Delta}_{j,t} = \alpha + \delta X_{j,t} + \lambda Y_{j,t} + \gamma_k + \eta_t + \epsilon_{j,t} \tag{10}$$

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

where the subscript j indicates that the variables are now measured at the level of the plan sponsor. The additional variable $Y_{j,t}$ is a vector of sponsor characteristics including Altman's z-score (Altman and La Fleur, 1981), the firm's consolidated leverage ratio (Shivdasani and Stefanescu, 2010), the relative size of the pension plan(s) to the size of the plan sponsor and other firm characteristics such as Tobin's q or the sponsor's dividend yield. A formal definition of all variables is provided in Appendix Table 2.[27]

Table 12 presents results of the first stage regression with OLS estimates displayed in Panel A and firm fixed-effect estimates displayed in Panel B. Focusing first on the plan specific variables displayed in Panel A, we can see that the impact of plan specific factors is qualitatively similar to the results shown in Table 5 for the full sample of plans: large plans, plans with a higher duration of liabilities and/or more risky investments make higher discount rate assumptions (relative to the regulated discount rate). Turning to sponsor characteristics, results are slightly ambiguous. While credit risk proxies based on z-scores have a negative impact (high z-score values mean low credit risk) and consolidated leverage ratios do not matter statistically, only the relative size the pension plan (relative to the plan sponsor) affects discount rates positively. Panel B further shows that the effects of z-scores and relative plan size continue to be statistically significant when accounting for sponsor fixed effects.

In the second stage, we regress the part of the discount rate deviation that is left unexplained (i.e. the fitted regression residual $\hat{\epsilon}_{j,t}$ from the first stage regression) on the funding level of the pension plan, i.e.

$$\hat{\epsilon}_{j,t} = \kappa + \theta \mathrm{F}_{j,t} + \nu_{j,t} \tag{11}$$

The regression coefficient θ thus captures the remaining impact of the funding level on the

[27] In unreported analysis, we also investigate whether firms that engage in earnings management are more likely to employ favourable actuarial assumptions in the valuation of pension liabilities. Accounting accruals reflect discretionary decisions by management in order to separate the recognition of revenues and expenses from actual cash flows. Excessive use of such accounting accruals is typically associated with firms that engage in earnings management (Sloan, 1996). However, when using such an accrual measure we do not find any relation to the opportunistic choice of actuarial assumptions.

difference in discount rates that can not be explained by the factors used in the first stage regression. In other words, if the marginal effect of the funding level on discount rates is captured by the set of variables used in the first stage regression, then the coefficient estimate θ should be indistinguishable from zero in the second stage regression. However, Table 13 confirms the previous evidence. The funding status continues to be significant (both for OLS and firm fixed effect estimation), also when it is split into a positive a negative component. Columns 2 and 3 show that a 10 percentage point increase in the level of underfunding increases the difference between accrued and current liability discount rates by 7 to 9 basis points.[28]

The missing impact of consolidated leverage in the first stage regression is surprising. To better understand the result, we sort plan sponsors into two groups using the median consolidated leverage as the threshold. The sort generates substantial variation in leverage ratios: leverage equals 18 (55) percent for the low (high) group. We repeat the exercise using also z-score measures and find again that z-scores differ substantially across the two groups.[29] Because both sorts univariately identify high (low) credit risk sponsors, we are able to test whether non-linearities in those variables drive their missing impact in the first stage regression (and thereby the significance of the funding variable in the second stage regression).

We therefore re-estimate the first stage regression separately for each group and use the residuals again in the second stage. Table 14 displays the corresponding results and confirms that funding is negatively correlated with the difference in discount rate assumptions. The effect is again driven by underfunded pension plans and, most importantly, it is statistically significant in each of the four groups.

Overall, our findings suggest that the impact of funding on actuarial assumptions is unlikely to be driven by credit risk - as perhaps mostly emphasized by the fact that the relation robustly holds even among plan sponsors with low level of perceived credit risk. Instead, the residual statistically significant impact of the funding status is consistent with the previous explanation that simple

[28]We also estimate the effect of funding and the firm specific variables Y jointly in one multivariate regression. In this case, the partial impact of funding is stronger than using the two-step approach. Results are available upon request.

[29]For the low (high) z-score group, the z-score value is 2.4 (10.5).

cash management considerations drive excess discount rate assumptions.

5 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 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, Congress signed into law the MAP-21 Act. This bill essentially gave sponsors of corporate DB pension plans that use the segmented yield curve concept a funding relief. The reason is that under MAP-21, segment yield curves are computed over a longer period than before. Because historically yields are higher than current rates, this change effectively increases discount rates and decreases pension liabilities.[30].

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

[30] See Section 2 for full details

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

$$update_{i,t} = \alpha + \theta^P F^+_{i,t-1} + \theta^N F^-_{i,t-1} + \delta X_{i,t-1} + \gamma_k + \eta_t + \epsilon_{i,t} \tag{12}$$

where t is the year of the adoption of the MAP-21 legislation, $update_{i,t}$ is a dummy variable equal to one in case the plan adopted MAP-21, 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. The funding variables are the degrees of overfunding or underfunding ($F^+_{i,t-1} = max(F, 0)$ and $F^-_{i,t-1} = max(-F, 0)$). Hence, a positive coefficient on the $F^-_{i,t-1}$ underfunding variable means that more underfunded plans are more likely to be early adopters of the new legislation.

Table 15 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. For example, plans that switched were underfunded by an average of 8 percent, while plans that did not switch were overfunded by 6 percent. 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.

6 Conclusion

The analysis presented in this paper suggests that pension funds – when left with the choice – use regulatory leeway to their own benefit. 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.

The difference between the two liability measures is due to deviations in discount rate and life expectancy assumptions. We show that the funding status of a pension plan has a direct impact on both of them: underfunded plans are substantially more likely to employ lower life expectancy assumptions (relative to the regulated measure) and also to use higher discount rate assumptions. The effect persists both in the cross-section of plans and over time and it serves to reduce cash contributions to the pension plan. Finally, we show that the opportunistic behavior is not alternatively explained by the credit risk of the plan sponsor as the relation exists even among plans with low consolidated leverage ratios. Instead, it seems that plans use regulatory leeway as a simple cash management tool.

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. 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 adoption of MAP-21 until 2013.

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Figure 1: **Distribution of the pension liability gap meausre**

The figure plots the distribution of the pension liability gap measure G, where

$$G_{i,t} = \frac{CL_{i,t} - AL_{i,t}}{AL_{i,t}}$$

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.

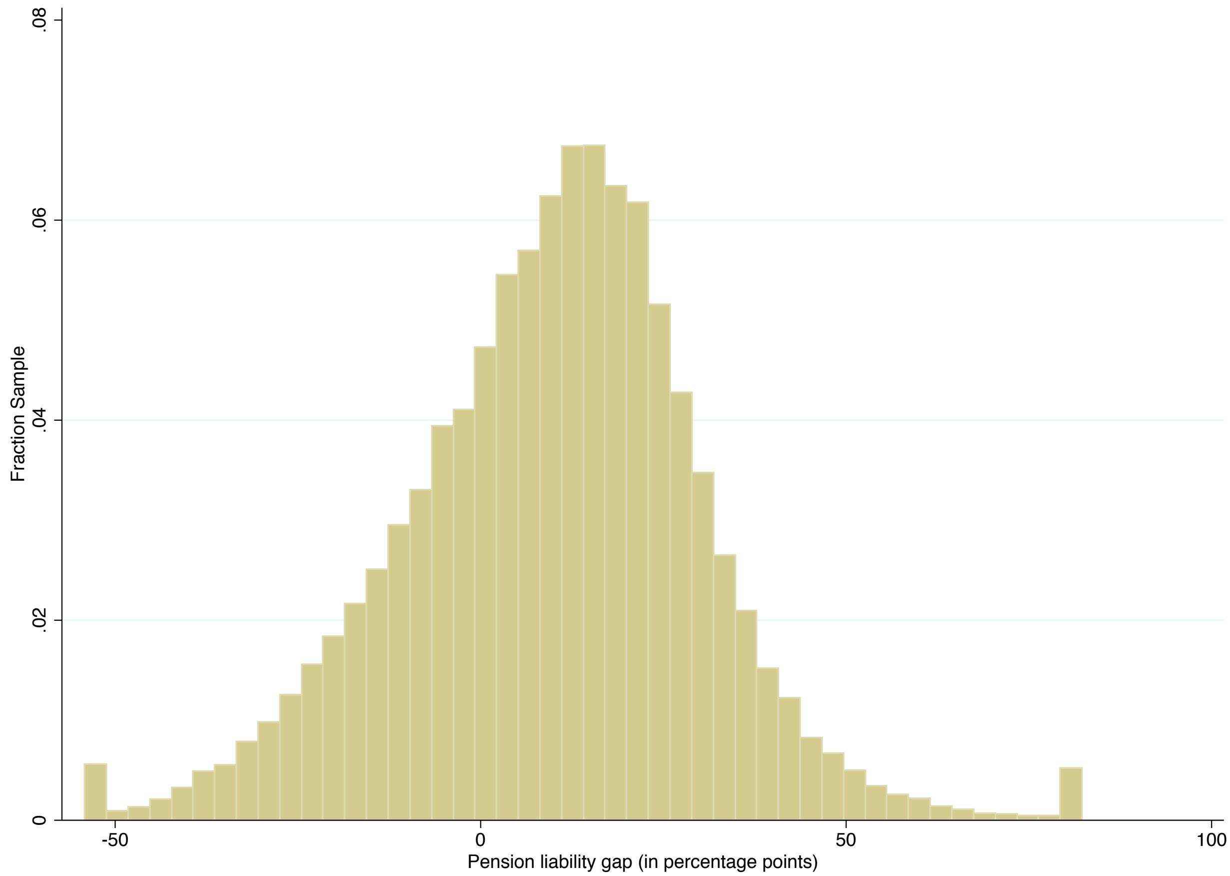


Figure 2: **Univariate relation between the funding status and the pension liability gap**

The figure plots the univariate relation between the funding status F of the pension plan (horizontal axis) and the corresponding pension liability gap measure G. The funding status F is defined as the difference between pension assets and pension liabilities, measured relative to pension liabilities. The pension liability gap G is defined as the percentage difference between current (CL) and accrued liabilities (AL). The kernel regression estimation is performed using an Epanechnikov kernel, with a bandwith of 10. A 95% confidence interval is included in the shaded region. The relation is displayed for funding levels within the 1 and 99 percentile values. 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.

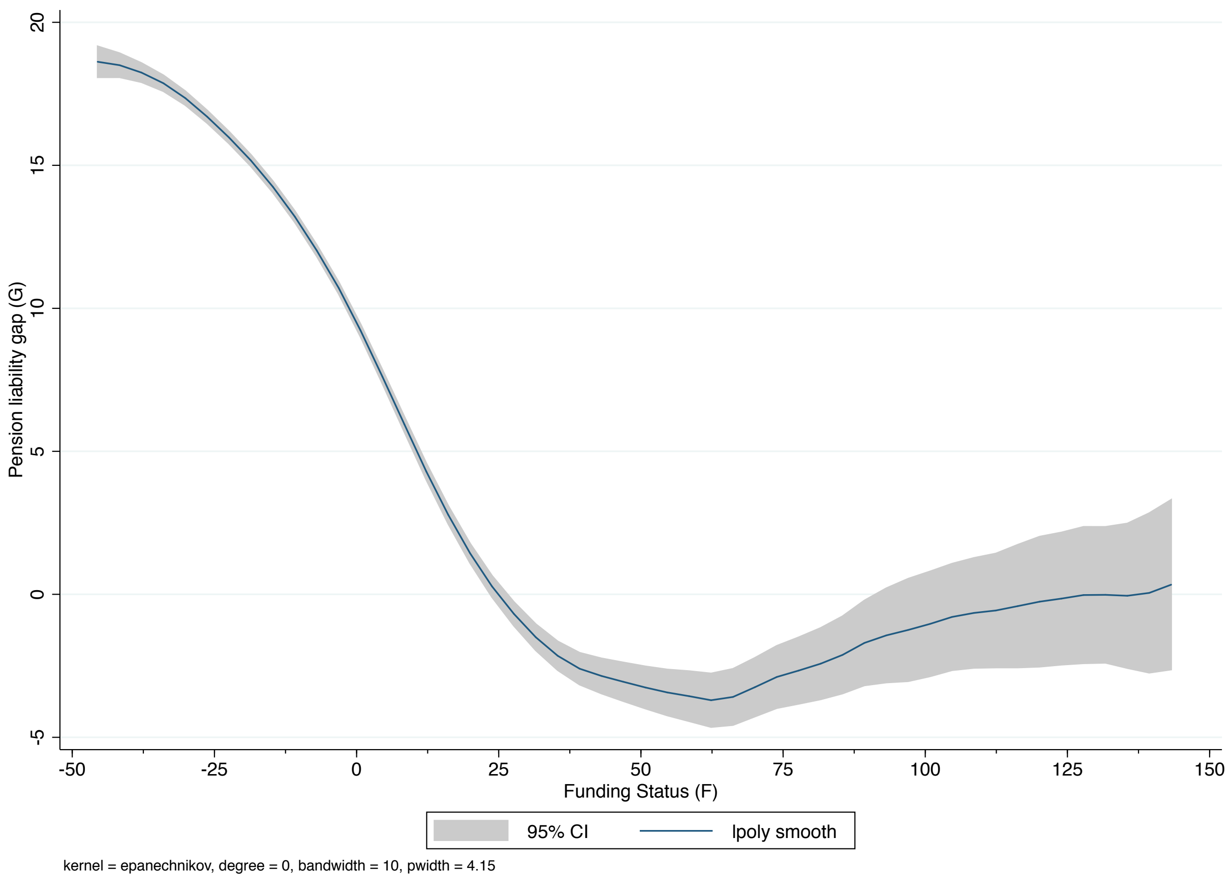
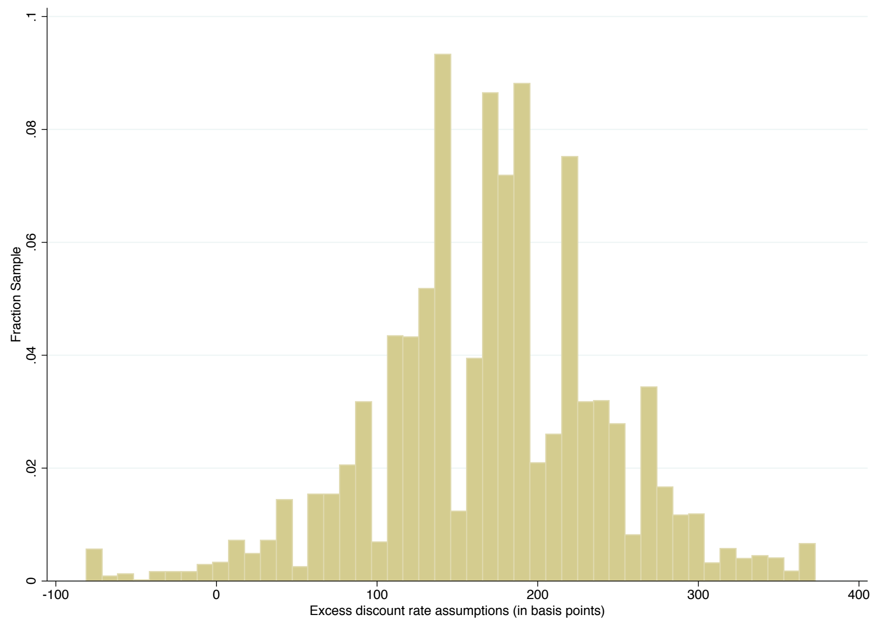


Figure 3: **Excess actuarial assumptions**

The figure contains a frequency distribution of excess actuarial assumptions, which are defined as the difference in actuarial assumptions used under the accrued liability (AL) and the current liability (CL) measure. Panel A displays excess discount rate assumptions ($r^{\Delta}_{i,t} = r^{AL}_{i,t} - r^{CL}_{i,t}$ where $r^{AL}_{i,t}$ ($r^{CL}_{i,t}$) is the discount rate assumptions under the AL (CL) measure). Panel B shows excess life expectancy assumptions ($LE^{\Delta}_{i,t} = LE^{AL}_{i,t} - LE^{CL}_{i,t}$ where $LE^{AL}_{i,t}$ ($LE^{CL}_{i,t}$) is the life expectancy assumption under the AL (CL) 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: Excess discount rate assumptions



Panel B: Excess life expectancy assumptions

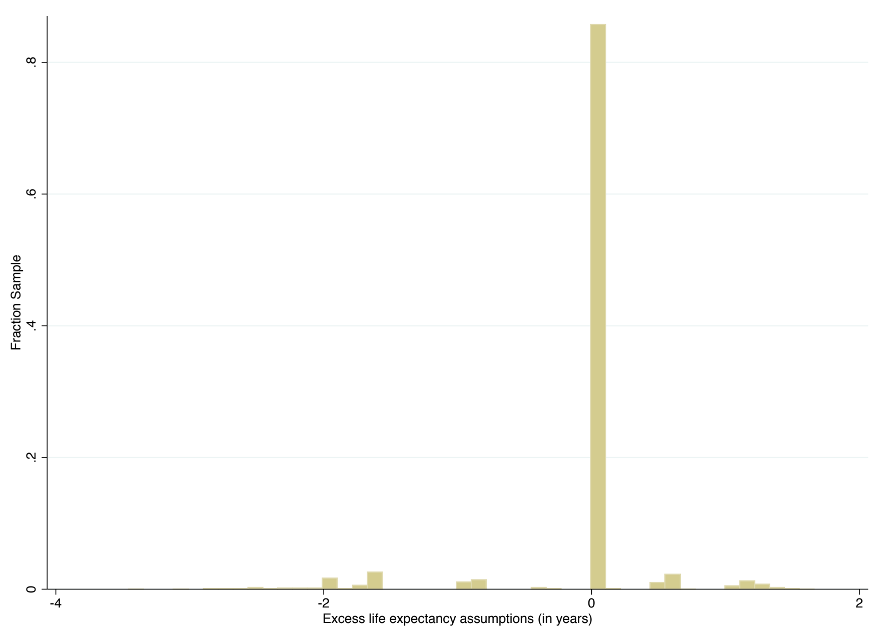


Table 1: **Summary statistics of main variables (Form 5500 Sample)**

This table displays average (Panel A) and median (Panel B) values of the main variables used in this paper. Actuarial liabilities (AL), current liabilities (CL) and pension assets (PA) are stated in million U.S. dollars, discount rates (r^{AL}, r^{CL} and r^{Δ}) are measured in basis points, life expectancy variables (LE^{AL}, LE^{CL} and LE^{Δ}) are computed at the average retirement age of the pension plan and are measured in years and $Size$ is the natural logarithm of pension assets. All other variables including the pension liability gap (G), the funding status (F), the ratio of retired to all plan participants (Dur) and the fraction invested in risky assets ($Risky$) are measured in percentage points. Exact variable definitions are given in Appendix Table 2. Sample of 11,963 U.S. single employer defined benefit pension plans and 48,880 plan-years, 1999-2007.

$Year$	$Plans$	AL	CL	G	PA	F	r^{AL}	r^{CL}	r^{Δ}	LE^{AL}	LE^{CL}	LE^{Δ}	$Size$	Dur	$Risky$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A: Average Values															
1999	5736	67	74	7	91	16	806	642	163	17.17	17.32	-0.15	2.48	81	85
2000	5918	60	68	10	88	14	806	623	182	17.25	17.37	-0.12	2.47	81	84
2001	7349	74	85	12	96	2	806	611	195	17.29	17.39	-0.09	2.54	81	84
2002	7290	82	94	6	93	-3	803	653	150	17.36	17.43	-0.07	2.54	80	83
2003	6799	92	107	9	91	-15	796	634	162	17.39	17.45	-0.06	2.51	79	85
2004	5651	102	113	7	114	-4	794	644	149	17.43	17.47	-0.04	2.72	79	86
2005	4963	100	114	12	117	-5	787	603	183	17.33	17.37	-0.03	2.69	78	86
2006	2624	59	69	16	68	-8	778	574	204	17.15	17.19	-0.05	2.48	78	85
2007	2550	91	109	18	115	-4	773	578	194	18.12	18.15	-0.03	2.67	78	85
Avg.	5959	81	93	10	97	0	797	625	172	17.35	17.43	-0.08	2.56	80	85
Panel B: Median Values															
1999	5736	9	9	8	10	7	800	655	152	16.95	16.95	0.00	2.30	85	97
2000	5918	9	9	11	10	5	800	631	169	16.95	16.95	0.00	2.33	84	97
2001	7349	10	11	13	11	-6	800	621	181	16.95	16.95	0.00	2.36	84	96
2002	7290	11	11	7	10	-10	800	685	130	16.95	16.95	0.00	2.35	83	94
2003	6799	11	12	10	10	-20	800	665	148	16.95	16.95	0.00	2.31	83	93
2004	5651	13	13	9	12	-8	800	655	145	17.26	16.95	0.00	2.50	82	95
2005	4963	12	13	14	12	-10	800	610	190	16.95	16.95	0.00	2.47	81	95
2006	2624	10	11	17	10	-12	800	577	223	16.19	16.19	0.00	2.29	81	94
2007	2550	11	12	20	11	-9	800	578	219	18.23	17.07	-0.88	2.44	80	95
Avg.	5918	10	11	11	11	-8	800	631	172	16.95	16.95	0.00	2.37	83	95

Table 2: **Changes in excess actuarial assumptions**

This table shows the mean change in excess actuarial assumptions and the number of increases, nonchanges and decreases for all firms in the sample. Panel A displays the change in excess discount rate assumptions ($r^{\Delta}_{i,t} - r^{\Delta}_{i,t-1}$), Panel B the change in excess life expectancy assumptions ($LE^{\Delta}_{i,t} - LE^{\Delta}_{i,t-1}$). 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.

Year	Change (1)	Number of increases (2)	Number no change (3)	Number of decreases (4)	Total count (5)	% of firms increasing (6)	% of firms decreasing (7)
Panel A: Change in excess discount rates							
2000	21.74	3201	40	184	5918	0.54	0.03
2001	13.20	4474	34	271	7349	0.61	0.04
2002	-45.26	1118	64	4916	7290	0.15	0.67
2003	11.33	4639	86	1322	6799	0.68	0.19
2004	-10.94	3757	38	1272	5651	0.66	0.23
2005	34.69	3615	33	468	4963	0.73	0.09
2006	26.30	2253	15	153	2624	0.86	0.06
2007	-5.98	23	71	1683	2550	0.01	0.66
Avg.	2.09	2796	44	1271	5959	0.47	0.21
Panel B: Change in excess life expectancy assumptions							
2000	0.02	55	3363	7	5918	0.01	0.00
2001	0.02	66	4705	8	7349	0.01	0.00
2002	0.02	76	6007	15	7290	0.01	0.00
2003	0.01	95	5936	16	6799	0.01	0.00
2004	0.01	59	5002	6	5651	0.01	0.00
2005	0.01	74	4030	12	4963	0.01	0.00
2006	0.01	33	2380	8	2624	0.01	0.00
2007	-0.36	456	0	1321	2550	0.18	0.52
Avg.	-0.01	81	3951	78	5959	0.02	0.03

Table 3: **Excess actuarial assumptions and the pension liability gap**

This table displays results when estimating the effect of excess actuarial assumptions on the gap variable $G_{i,t}$, which is defined as the relative difference between current pension liabilities (CL) and accrued pension liabilities (AL):

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

where $r^{\Delta}_{i,t}$ denotes excess discount rate assumptions ($r^{\Delta}_{i,t} = r^{AL}_{i,t} - r^{CL}_{i,t}$), $LE^{\Delta}_{i,t}$ is excess life expectancy assumptions ($LE^{\Delta}_{i,t} = LE^{AL}_{i,t} - LE^{CL}_{i,t}$), $X_{i,t}$ 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). Values in parentheses denote standard errors which are adjusted for heteroskedasticity and, under fixed effect estimation, are computed according to Discroll and Kraay (1998) to account for possible cross-sectional and temporal interdependence among the error terms. $^+$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. 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			Fixed effects		
	(1)	(2)	(3)	(4)	(5)	(6)
$r^{\Delta}_{i,t}$	0.15**	0.15**	0.14**	0.14**	0.14**	0.13**
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
$LE^{\Delta}_{i,t}$	-3.21**	-2.90**	-2.89**	-1.65**	-1.87**	-2.23**
	(0.18)	(0.17)	(0.17)	(0.15)	(0.14)	(0.34)
$Size_{i,t}$		-1.20**	-0.89**		3.00*	-0.41
		(0.05)	(0.05)		(1.30)	(0.66)
$Duration_{i,t}$		-0.23**	-0.19**		-0.11**	-0.01
		(0.00)	(0.00)		(0.03)	(0.01)
$Risky_{i,t}$		0.02**	0.01**		0	0.00
		(0.00)	(0.00)		(0.01)	(0.00)
Time dummies	no	no	yes	no	no	yes
Industry dummies	no	no	yes	no	no	yes
N	48880	48880	48880	48880	48880	48880
R^2	0.26	0.30	0.34	0.31	0.32	0.36

Table 4: **Plan funding and excess life expectancy assumptions**

This table displays results when estimating the impact of the funding status on excess life expectancy assumptions. The estimation is based on a logit model where

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

where $y_{i,t}$ is a dummy variable equal to one in case the freely chosen life expectancy assumption is below the one mandated by the government (i.e. $LE^{\Delta}_{i,t} < 0$), $F_{i,t}$ is the funding status of plan i at time t, the vector $X_{i,t}$ denotes 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 an industry-fixed effect and η_t are time-fixed effects. In column (5), the funding level is split into a positive (overfunded) and negative (underfunded) component (which records negative funding levels with a positive sign). $^{+}$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. 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.

	Logit Regression				
Control Variables	(1)	(2)	(3)	(4)	(5)
$Funding_{i,t}$ (F)	-0.008**	-0.005**	-0.007**	-0.007**	
	(0.001)	(0.001)	(0.001)	(0.001)	
$Size_{i,t}$		-0.213**	-0.269**	-0.263**	-0.254**
		(0.011)	(0.012)	(0.013)	(0.013)
$Duration_{i,t}$		-0.007**	-0.007**	-0.007**	-0.007**
		(0.001)	(0.001)	(0.001)	(0.001)
$Risky_{i,t}$		-0.012**	-0.014**	-0.014**	-0.014**
		(0.001)	(0.001)	(0.001)	(0.001)
$Overfunding_{i,t}$ (F^{+})					-0.004**
					(0.001)
$Underfunding_{i,t}$ (F^{-})					0.012**
					(0.002)
Time dummies	no	no	yes	yes	yes
Industry dummies	no	no	no	yes	yes
N	48880	48880	48880	48880	48880

Table 5: **Plan funding and excess discount rate assumptions**

This table displays results when estimating the impact of the funding status on excess discount rate assumptions. The regression is given by

$$r^{\Delta}_{i,t} = \alpha + \theta F_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t}$$

where $r^{\Delta}_{i,t}$ denotes excess discount rate assumptions ($r^{\Delta}_{i,t} = r^{AL}_{i,t} - r^{CL}_{i,t}$), $F_{i,t}$ is the funding status of plan i at time 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 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). Values in parentheses denote standard errors which are adjusted for heteroskedasticity and, under fixed effect estimation, are computed according to Discroll and Kraay (1998) to account for possible cross-sectional and temporal interdependence among the error terms. $^+$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. 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		Fixed effect	
Control Variables	(1)	(2)	(3)	(4)
$Funding_{i,t}$ (F)	-0.47**		-0.56**	
	(0.01)		(0.17)	
$Size_{i,t}$	14.53**	15.41**	15.86**	22.14**
	(0.20)	(0.20)	(4.72)	(6.77)
$Duration_{i,t}$	0.07**	0.11**	-0.06	-0.02
	(0.02)	(0.02)	(0.04)	(0.04)
$Risky_{i,t}$	0.30**	0.33**	0.03	0.07**
	(0.02)	(0.02)	(0.02)	(0.01)
$Overfunding_{i,t}$ (F^+)		-0.24**		-0.36**
		(0.01)		(0.09)
$Underfunding_{i,t}$ (F^-)		1.34**		1.32**
		(0.03)		(0.35)
Time dummies	yes	yes	yes	yes
Industry dummies	yes	yes	yes	yes
N	48880	48880	48880	48880
R^2	0.21	0.23	0.27	0.29

Table 6: **Plan funding and actuarial discount rate assumptions**

This table displays results when estimating the impact of the funding status on excess discount rate assumptions. The regression is given by

$$r_{i,t}^{AL} = \alpha + \theta F_{i,t} + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t}$$

where $r_{i,t}^{AL}$ denotes the discount rate assumption under the AL measure, $F_{i,t}$ is the funding status of plan i at time 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 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). Values in parentheses denote standard errors which are adjusted for heteroskedasticity and, under fixed effect estimation, are computed according to Discroll and Kraay (1998) to account for possible cross-sectional and temporal interdependence among the error terms. $^+$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. 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		Fixed effect	
Control Variables	(1)	(2)	(3)	(4)
$Funding_{i,t}$ (F)	-0.34**		-0.11**	
	(0.01)		(0.01)	
$Size_{i,t}$	11.58**	12.23**	2.82**	2.52**
	(0.18)	(0.18)	(0.74)	(0.78)
$Duration_{i,t}$	-0.05**	-0.02	0.01	0.00
	(0.02)	(0.02)	(0.02)	(0.02)
$Risky_{i,t}$	0.33**	0.34**	0.05**	0.05**
	(0.01)	(0.01)	(0.01)	(0.01)
$Overfunding_{i,t}$ (F^+)		-0.17**		-0.12**
		(0.01)		(0.01)
$Underfunding_{i,t}$ (F^-)		0.98**		0.07**
		(0.03)		(0.02)
Time dummies	yes	yes	yes	yes
Industry dummies	yes	yes	yes	yes
N	48880	48880	48880	48880
R^2	0.17	0.18	0.07	0.07

Table 7: **Plan funding and discount rate assumptions: cross-sectional evidence**

This table displays results when estimating the impact of the funding status on excess discount rate assumptions. The regression is given by

$$y_{i,t} = \alpha + \theta F_{i,t} + \delta X_{i,t} + \gamma_k + \epsilon_{i,t}$$

where $F_{i,t}$ is the funding status of plan i at time 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) and γ_k is an industry-fixed effect. In columns (1) and (2), the dependent variable y is $r^{\Delta}_{i,t}$ (denoting the difference in discount rate assumptions: $r^{\Delta}_{i,t} = r^{AL}_{i,t} - r^{CL}_{i,t}$). In columns (3) and (4), y is the discount rate under the AL measure ($r^{AL}_{i,t}$). 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 Fama-Macbeth regressions. Values in parentheses denote standard errors which are adjusted for heteroskedasticity. $^{+}$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. 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.

	$y = r^{\Delta}_{i,t}$		$y = r^{AL}_{i,t}$	
Control Variables	(1)	(2)	(3)	(4)
$Funding_{i,t}$ (F)	-0.48**		-0.38**	
	(0.06)		*(0.03)*	
$Size_{i,t}$	13.71**	14.40**	11.50**	12.17**
	(0.97)	(0.95)	(0.23)	(0.23)
$Duration_{i,t}$	0.04	0.08+	-0.06*	-0.03
	(0.04)	(0.04)	(0.02)	(0.02)
$Risky_{i,t}$	0.31**	0.32**	0.32**	0.34**
	(0.01)	(0.01)	(0.02)	(0.02)
$Overfunding_{i,t}$ (F^{+})		-0.22**		-0.16**
		(0.02)		(0.02)
$Underfunding_{i,t}$ (F^{-})		1.18**		0.99**
		(0.18)		(4.09)
Industry dummies	yes	yes	yes	yes
N	48880	48880	48880	48880
R^2	0.13	0.14	0.13	0.14

Table 8: **Plan funding and discount rate assumptions: time-series evidence**

This table displays results when estimating the impact of changes in the funding status on changes in discount rate assumptions. The regression is given by

$$\Delta y_{i,t} = \alpha + \theta\left(\Delta F_{i,t}\right) + \delta X_{i,t} + \gamma_k + \eta_t + \epsilon_{i,t}$$

where $\Delta F_{i,t} = F_{i,t} - F_{i,t-1}$ is changes in the funding status of plan i at time 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 an industry-fixed effect and η_t are time-fixed effects. In columns (1) and (2), the dependent variable $\Delta y_{i,t}$ is the change in excess discount rate assumptions ($r^{\Delta}_{i,t} - r^{\Delta}_{i,t-1}$). In columns (3) and (4), $\Delta y_{i,t}$ is the change in the discount rate under the AL measure ($r^{AL}_{i,t} - r^{AL}_{i,t-1}$). In columns (2) and (4), funding changes are split into changes for overfunded and underfunded plans (note that negative funding levels are recorded with a positive sign). The estimation is done using Fama-Macbeth regressions. Values in parentheses denote standard errors which are adjusted for heteroskedasticity. $^{+}$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. 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.

	$\Delta y_{i,t} = \Delta r^{\Delta}_{i,t}$		$\Delta y_{i,t} = \Delta r^{AL}_{i,t}$	
Control Variables	(1)	(2)	(3)	(4)
Change in Funding$_{i,t}$ (ΔF)	-0.62**		-0.03+	
	(0.03)		*(0.02)*	
$Size_{i,t}$	-0.52**	-0.33+	-0.15	-0.16
	(0.18)	(0.18)	(0.10)	(0.10)
$Duration_{i,t}$	0.01	0.02	0.02+	0.02+
	(0.02)	(0.02)	(0.01)	(0.01)
$Risky_{i,t}$	0.01	0.02	0.03**	0.03**
	(0.01)	(0.01)	(0.01)	(0.01)
Change in Overfunding$_{i,t}$ (ΔF^{+})		-0.30**		-0.04*
		(0.03)		(0.02)
Change in Underfunding$_{i,t}$ (ΔF^{-})		1.53**		-0.02
		(0.05)		(0.02)
Industry dummies	yes	yes	yes	yes
N	33730	33730	33730	33730
R^2	0.29	0.31	0.01	0.01

Table 9: **Excess actuarial assumptions and cash contributions**

This table displays results when estimating the effect of excess actuarial assumptions on the cash contributions $cost_{i,t}$ to the pension fund:

$$\text{normal\_cost}_{i,t} = \alpha + \beta_1 r^{\Delta}_{i,t} + \beta_2 LE^{\Delta}_{i,t} + \beta_3 Part_{i,t} + \gamma_k + \eta_t +$$

where $\text{normal\_cost}_{i,t}$ is the ratio of the plan's normal cash contributions (normal cost) to the value of the pension assets, $r^{\Delta}_{i,t}$ denotes excess discount rate assumptions ($r^{\Delta}_{i,t} = r^{AL}_{i,t} - r^{CL}_{i,t}$), $LE^{\Delta}_{i,t}$ is excess life expectancy assumptions ($LE^{\Delta}_{i,t} = LE^{AL}_{i,t} - LE^{CL}_{i,t}$), $Part$ is the number of active plan participants (scaled again by the value of pension 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. Values in parentheses denote standard errors which are adjusted for heteroskedasticity and, under fixed effect estimation, are computed according to Discroll and Kraay (1998) to account for possible cross-sectional and temporal interdependence among the error terms. $^{+}$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. 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.

	(1)	(2)	(3)
Panel A: OLS Estimation			
$r^{\Delta}_{i,t}$	-0.007**	-0.004**	-0.002**
	(0.000)	(0.000)	(0.000)
$LE^{\Delta}_{i,t}$	0.367**	0.513**	0.407**
	(0.047)	(0.044)	(0.043)
$Part_{i,t}$		0.000**	0.000**
		(0.000)	(0.000)
Time dummies	no	no	yes
Industry dummies	no	no	yes
N	48880	48880	48880
R^2	0.01	0.28	0.31
Panel B: Fixed effect estimation			
$r^{\Delta}_{i,t}$	-0.006**	-0.003**	-0.001**
	(0.002)	(0.001)	(0.000)
$LE^{\Delta}_{i,t}$	-0.105**	0.038	0.03
	(0.038)	(0.064)	(0.052)
$Part_{i,t}$		0.000**	0.000**
		(0.000)	(0.000)
Time dummies	no	no	yes
Industry dummies	no	no	yes
N	48880	48880	48880
R^2	0.01	0.38	0.39

Table 10: **Potential reduction in the minimum funding contribution**

This table displays the potential reduction in the minimum funding contribution (MFC) for the average pension fund in our sample, where

$$MFC = \text{normal\_cost} + \left(\frac{\text{AL - PA}}{n}\right)$$

The value of pension assets (PA) is \$96 million, normal costs (NC) are 4.23% of this value and the amortization period (n) is 10 years. The amortization payment ($Amort$) is given by the difference between accrued liabilities (AL) and the asset value of \$96 million, divided by the amortization period of 10 years. Columns (1) to (4) compute the MFC under a base case scenario that varies accrued liabilities from \$96 million to \$120 million. Columns (5) to (8) compute the potential MFC in case discount rates under the AL measure are increased by 10 basis points ($\Delta r^{AL} = 10$) and life expectancy assumptions are reduced by a year ($\Delta LE^{AL} = -1$). The corresponding reductions in AL are 1.5% (for Δr^{AL}) and 3% (for ΔLE^{AL}). Normal costs decrease by 7 basis points (for Δr^{AL}) and 37 basis points (for ΔLE^{AL}). Column (9) displays the potential reduction in the corresponding MFC and is measured in percentage points. 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.

Base case				$\Delta r^{AL} = 10$ & $\Delta LE^{AL} = -1$				
AL	$Amort$	NC	MFC	AL	$Amort$	NC	MFC	ΔMFC
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
96	0.0	4.1	4.1	91.7	0.0	3.6	3.6	-10
97	0.1	4.1	4.2	92.6	0.0	3.6	3.6	-13
98	0.2	4.1	4.3	93.6	0.0	3.6	3.6	-15
99	0.3	4.1	4.4	94.5	0.0	3.6	3.6	-17
100	0.4	4.1	4.5	95.5	0.0	3.6	3.6	-18
101	0.5	4.1	4.6	96.5	0.0	3.6	3.7	-19
102	0.6	4.1	4.7	97.4	0.1	3.6	3.8	-19
103	0.7	4.1	4.8	98.4	0.2	3.6	3.9	-19
104	0.8	4.1	4.9	99.3	0.3	3.6	4.0	-18
105	0.9	4.1	5.0	100.3	0.4	3.6	4.1	-18
106	1.0	4.1	5.1	101.2	0.5	3.6	4.2	-18
107	1.1	4.1	5.2	102.2	0.6	3.6	4.3	-18
108	1.2	4.1	5.3	103.1	0.7	3.6	4.4	-17
109	1.3	4.1	5.4	104.1	0.8	3.6	4.4	-17
110	1.4	4.1	5.5	105.1	0.9	3.6	4.5	-17
111	1.5	4.1	5.6	106.0	1.0	3.6	4.6	-17
112	1.6	4.1	5.7	107.0	1.1	3.6	4.7	-16
113	1.7	4.1	5.8	107.9	1.2	3.6	4.8	-16
114	1.8	4.1	5.9	108.9	1.3	3.6	4.9	-16
115	1.9	4.1	6.0	109.8	1.4	3.6	5.0	-16
116	2.0	4.1	6.1	110.8	1.5	3.6	5.1	-16
117	2.1	4.1	6.2	111.7	1.6	3.6	5.2	-15
118	2.2	4.1	6.3	112.7	1.7	3.6	5.3	-15
119	2.3	4.1	6.4	113.6	1.8	3.6	5.4	-15
120	2.4	4.1	6.5	114.6	1.9	3.6	5.5	-15

Table 11: **Summary statistics of main variables (Compustat subsample)**

This table displays average (Panel A) and median (Panel B) values of the main actuarial variables. Detailed variable definitions and an explanation of the aggregation procedure are in Appendix Table 2. Actuarial liabilities (AL), current liabilities (CL) and pension assets (PA) are stated in million U.S. dollars, discount rates (r^{AL}, r^{CL} and r^{Δ}) are measured in basis points, life expectancy variables (LE^{AL}, LE^{CL} and LE^{Δ}) are computed at the average retirement age of the pension plan and are measured in years and size is the natural logarithm of pension assets. All other variables including the pension liability gap (G), the funding status (funding), the ratio of retired to all plan participants (duration) and the fraction invested in risky assets (risky) are fractions. Sample of 707 U.S. single employer DB plan sponsors and 2,797 plan-years, 1999-2007.

Year	*Plans* (1)	*AL* (2)	*CL* (3)	*G* (4)	*PA* (5)	*F* (6)	r^{AL} (7)	r^{CL} (8)	r^{Δ} (9)	LE^{AL} (10)	LE^{CL} (11)	LE^{Δ} (12)	*Size* (13)	*Dur* (14)	*Risky* (15)
Panel A: Average Values															
1999	373	270	308	13	369	19	828	641	188	17.63	17.77	-0.14	4.11	78	89
2000	365	294	341	17	455	17	828	622	206	17.71	17.81	-0.09	4.07	79	87
2001	419	542	625	17	715	3	828	607	221	17.80	17.88	-0.07	4.40	77	87
2002	420	473	556	14	546	-6	822	633	189	17.83	17.87	-0.04	4.32	78	86
2003	406	533	633	16	561	-15	816	615	201	17.95	17.97	-0.02	4.39	76	88
2004	323	495	565	11	571	0	809	642	167	18.01	18.04	-0.02	4.54	75	89
2005	287	603	706	17	713	-3	809	605	204	17.98	17.96	0.03	4.62	75	91
2006	98	564	664	21	695	-8	799	574	225	17.86	17.83	0.04	4.09	72	89
2007	106	961	1170	23	1288	0	793	577	216	18.95	18.74	0.24	4.66	73	91
Avg.	356	479	560	16	592	2	819	620	199	17.88	17.93	-0.04	4.34	77	88
Panel B: Median Values															
1999	373	50	54	13	65	8	825	655	195	17.73	17.73	0.00	4.18	81	99
2000	365	44	50	17	61	8	825	631	217	17.73	17.73	0.00	4.10	83	98
2001	419	67	82	18	78	-5	825	621	229	17.73	17.73	0.00	4.35	79	96
2002	420	70	80	14	72	-14	825	675	175	17.73	17.73	0.00	4.28	79	95
2003	406	81	96	16	76	-20	800	665	185	17.73	17.73	0.00	4.33	78	94
2004	323	81	87	13	89	-4	800	655	168	17.73	17.73	0.00	4.48	78	96
2005	287	80	95	18	90	-6	800	610	190	17.73	17.73	0.00	4.50	76	96
2006	98	42	53	22	47	-8	800	577	223	17.73	17.73	0.00	3.84	74	96
2007	106	62	84	25	77	-3	800	578	222	18.79	18.65	1.16	4.34	74	97
Avg.	373	65	76	16	73	-6	800	629	195	17.73	17.73	0.00	4.29	79	96

Table 12: **Credit risk, firm characteristics and excess discount rates**

This table displays results when estimating the effect of credit risk variables and firm characteristics on excess discount rate assumptions

$$r^{\Delta}_{j,t} = \alpha + \delta X_{j,t} + \lambda Y_{j,t} + \gamma_k + \eta_t + \epsilon_{j,t}$$

where $r^{\Delta}_{j,t}$ denotes excess discount rate assumptions ($r^{\Delta}_{j,t} = r^{AL}_{j,t} - r^{CL}_{j,t}$), $X_{j,t}$ 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 plan-fixed effect (in which case $k = j$), η_t are time-fixed effects and the variable $Y_{j,t}$ contains proxies for the firm's credit risk. All regressions include time dummies, Panel A also includes industry dummies. Values in parentheses denote standard errors which are adjusted for heteroskedasticity and, under fixed effect estimation, are computed according to Discroll and Kraay (1998) to account for possible cross-sectional and temporal interdependence among the error terms. $^+$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. Detailed variable definitions and an explanation of the aggregation procedure are in Appendix Table 2. Sample of 707 U.S. single employer DB plan sponsors and 2,797 plan-years, 1999-2007.

Control Variables	(1)	(2)	(3)	(4)	(5)
Panel A: OLS Estimation					
$\text{Size}_{j,t}$	14.40**	14.41**	13.68**	13.45**	13.46**
	(0.64)	(0.64)	(0.69)	(0.70)	(0.70)
$\text{Dur}_{j,t}$	0.34**	0.35**	0.39**	0.38**	0.38**
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
$\text{Risky}_{j,t}$	0.17*	0.17*	0.18**	0.18**	0.19**
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
$\text{Z-score}_{j,t}$	0.90**	1.00**	0.85**	0.75**	0.75**
	(0.18)	(0.22)	(0.23)	(0.24)	(0.24)
$\text{Lev}_{j,t}$		5.08	-2.53	2.83	2.97
		(6.44)	(7.02)	(7.45)	(7.45)
Rel. $\text{Size}_{j,t}$			24.83**	24.43**	24.45**
			(8.40)	(8.43)	(8.45)
$Q_{j,t}$				3.40*	3.38*
				(1.62)	(1.62)
$\text{Div}_{j,t}$					-15.06
					(48.13)
N	2797	2797	2797	2797	2797
R^2	0.24	0.24	0.24	0.24	0.24
Panel B: Fixed Effect Estimation					
$\text{Size}_{j,t}$	8.53**	8.26**	6.11**	6.00**	6.02**
	(1.82)	(1.75)	(1.60)	(1.54)	(1.54)
$\text{Dur}_{j,t}$	0.03	0.02	0.02	0.02	0.02
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
$\text{Risky}_{j,t}$	0.04	0.05	0.05	0.05	0.05
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
$\text{Z-score}_{j,t}$	0.39*	0.60**	0.43*	0.60**	0.60**
	(0.17)	(0.20)	(0.18)	(0.13)	(0.13)
$\text{Lev}_{j,t}$		18.58**	6.65	-3.86	-4.20
		(6.89)	(5.60)	(5.46)	(5.34)
Rel. $\text{Size}_{j,t}$			57.10**	62.27**	62.24**
			(15.15)	(15.56)	(15.52)
$Q_{j,t}$				-7.04**	-6.99**
				(1.99)	(2.04)
$\text{Div}_{j,t}$					14.45
					(21.50)
N	2797	2797	2797	2797	2797
R^2	0.17	0.17	0.18	0.18	0.18

Table 13: **Plan funding und excess discount rates: Compustat subsample**

This table displays results when estimating the impact of funding on the deviation from the implied excess discount rate $\hat{\epsilon}_{j,t}$:

$$\hat{\epsilon}_{j,t} = \kappa + \theta F_{j,t} + \nu_{j,t}$$

where $\hat{\epsilon}_{j,t}$ is the residual from the first stage regression estimated in column (5) of Table 12 and F is the funding status of the pension plan. Columns (2) and (4) split the funding variable into a positive (overfunded) and negative (underfunded) component (which records negative funding levels with a positive sign). Values in parentheses denote standard errors which are adjusted for heteroskedasticity and, under fixed effect estimation, are computed according to Discroll and Kraay (1998) to account for possible cross-sectional and temporal interdependence among the error terms. $^+$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. Detailed variable definitions and an explanation of the aggregation procedure are in Appendix Table 2. Sample of 707 U.S. single employer DB plan sponsors and 2,797 plan-years, 1999-2007.

	OLS		Fixed effects	
Control variables	(1)	(2)	(3)	(4)
$Funding_{i,t}$ (F)	-0.42**		-0.33**	0
	(0.04)		(0.13)	
$Overfunding_{i,t}$ (F^+)		-0.33**		-0.17**
		(0.06)		(0.04)
$Underfunding_{i,t}$ (F^-)		0.74**		0.91**
		(0.12)		(0.28)
N	2797	2797	2797	2797
R^2	0.05	0.06	0.03	0.05

Table 14: **Plan funding, z-scores and consolidated leverage**

This table displays results when estimating the impact of funding on the deviation from the implied excess discount rate $\hat{\epsilon}_{j,t}$:

$$\hat{\epsilon}_{j,t} = \kappa + \theta \text{funding}_{j,t} + \nu_{j,t}$$

where $\hat{\epsilon}_{j,t}$ is the residual from the first stage regression estimated in column (5) of Table 12 and F is the funding status of the pension plan. Results are grouped by the z-score measure (low versus high) and the consolidated leverage ratio (low versus high). Regressions are performed separately for each group. Panel A employs a joint funding variable, Panel B splits the funding variable into a positive and a negative component (which records negative funding levels with a positive sign). Results are based on OLS estimation. Values in parentheses denote standard errors which are adjusted for heteroskedasticity and, under fixed effect estimation, are computed according to Discroll and Kraay (1998) to account for possible cross-sectional and temporal interdependence among the error terms. $^+$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. Detailed variable definitions and an explanation of the aggregation procedure are in Appendix Table 2. Sample of 707 U.S. single employer DB plan sponsors and 2,797 plan-years, 1999-2007.

	Z-Score		Leverage	
	Low	High	Low	High
Panel A: Joint funding variable				
$Funding_{i,t}$ (F)	-0.33**	-0.50**	-0.40**	-0.46**
	(0.05)	(0.07)	(0.06)	(0.06)
N	1399	1398	1399	1398
R^2	0.04	0.07	0.05	0.06
Panel B: Split funding variable				
$Overfunding_{i,t}$ (F^+)	-0.29**	-0.36**	-0.26**	-0.44**
	(0.07)	(0.08)	(0.07)	(0.08)
$Underfunding_{i,t}$ (F^-)	0.49**	1.02**	0.99**	0.50**
	(0.15)	(0.19)	(0.19)	(0.16)
N	1399	1398	1399	1398
R^2	0.04	0.07	0.06	0.06

Table 15: **The impact of funding levels to adapt the MAP-21 bill**

This table displays results when estimating the following prediction model

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

where $update_{i,t}$ is a dummy variable equal to one in case the plan adopted the MAP-21 legislation in 2012, $F^+_{i,t-1}$ ($F^-_{i,t-1}$) is the positive (negative) component of the plan's funding status (which records negative funding levels with a positive sign), 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. Values in parentheses denote standard errors which are adjusted for heteroskedasticity, the third line for each coefficient variable are odds ratios. $^+$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. 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)
$Overfunding_{i,t}$ (F^+)	-2.72**	-2.31**
	(0.32)	(0.30)
	0.07	0.10
$Underfunding_{i,t}$ (F^-)	3.28**	3.88**
	(0.48)	(0.51)
	26.63	48.52
$\text{Size}_{i,t}$		0.23**
		(0.02)
		1.26
$\text{Duration}_{i,t}$		0.56*
		(0.24)
		1.75
$\text{Risky}_{i,t}$		0.57**
		(0.15)
		1.77
Time dummies	no	no
Industry dummies	no	no
N	5218	5218

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]	
G	(CL - AL)/AL
funding	(PA - CL)/CL
r^{Δ}	r^{AL} - r^{CL}
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}	$LE^{AL} - LE^{CL}$
size	log(PA)
duration	1 - 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: Plan funding and excess life expectancy assumptions (1999 to 2006)

This table displays results when estimating the impact of the funding status on excess life expectancy assumptions. The estimation is based on a logit model where

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

where $y_{i,t}$ is a dummy variable equal to one in case the freely chosen life expectancy assumption is below the one mandated by the government (i.e. $LE^{\Delta}_{i,t} < 0$), $F_{i,t}$ is the funding status of plan i at time t, the vector $X_{i,t}$ denotes 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 an industry-fixed effect and η_t are time-fixed effects. In column (5), the funding level is split into a positive (overfunded) and negative (underfunded) component (which records negative funding levels with a positive sign). $^{+}$, *, ** indicate significance at the 10%, 5% and 1% level, respectively. Details on sample selection criteria are in Appendix Table 1, detailed variable definitions are in Appendix Table 2. Sample of 11,700 U.S. single employer defined benefit pension plans and 46,330 plan-years, 1999-2006.

	Logit Regression				
Control Variables	(1)	(2)	(3)	(4)	(5)
$Funding_{i,t}$ (F)	-0.008**	-0.003**	-0.006**	-0.006**	
	(0.001)	(0.001)	(0.001)	(0.001)	
$Size_{i,t}$		-0.325**	-0.299**	-0.295**	-0.286**
		(0.013)	(0.014)	(0.014)	(0.014)
$Duration_{i,t}$		-0.006**	-0.007**	-0.007**	-0.007**
		(0.001)	(0.001)	(0.001)	(0.001)
$Risky_{i,t}$		-0.015**	-0.015**	-0.015**	-0.015**
		(0.001)	(0.001)	(0.001)	(0.001)
$Overfunding_{i,t}$ (F^{+})					-0.004**
					(0.001)
$Underfunding_{i,t}$ (F^{-})					0.011**
					(0.002)
Time dummies	no	no	yes	yes	yes
Industry dummies	no	no	no	yes	yes
N	46330	46330	46330	46330	46330

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
- 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	$\sum_{t=1}^{3} \Delta$ interest (segment t)
update	1 if Δ interest $>$ -2 bp & Δ interest $<$ 2bp
size	log(PA)
duration	1 - 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.