# Corporate Pension Risk-Taking in a Low Interest Rate Environment*

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**Abstract**

We examine how funding deficit pressures shape the risk-taking of U.S. corporate defined-benefit (DB) pension plans and how targeted regulatory relief can mitigate these incentives. Using the 2012 MAP-21 reform, which temporarily eased funding pressure by revising discount rate calculations, we show that plans receiving greater relief significantly reduced their equity allocations and shifted toward safer assets. This de-risking was most pronounced among active plans and those sponsored by more financially constrained firms. Our findings demonstrate that targeted regulatory relief can curb risk-taking incentives, even without altering underlying economic conditions or financial reporting standards, and shed light on the likely (and unlikely) frictions driving such behavior.

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'[I]interest rate cuts by the Fed and moves to ease monetary conditions in Europe, China and Japan will drive pension funds... to hunt for better yields in riskier assets. This could be a dangerous course of action... Pension funds... have to hope that equity markets will continue to rally.'

'How pension plans are reacting to negative bond yields', *Financial Times*, August 4 2019

'I believe the biggest pension problem facing Corporate America and its investors is not the [funding] shortfall, but the risk mismatch between pension assets and liabilities.'

(Merton 2006, p.16)

## 1 Introduction

Changes in interest rates have profound effects on the funding status of defined-benefit (DB) pension plans. For example, the sharp rise in interest rates in 2022 pushed the funding status of U.S. corporate DB plans to its highest level since 2007. By contrast, the persistently low rates following the global financial crisis (GFC) contributed to widespread funding deficits, with the median funding ratio falling to 80%, indicating a 20% median deficit.[1] The secular decline in interest rates over the past decades has been a key source of these persistent funding pressures.

A large literature documents that sustained low interest rates encourage financial intermediaries and institutional investors, including pension funds, to shift toward riskier asset allocations in "search for yield" (e.g., Chodorow-Reich, 2014; Becker and Ivashina, 2015; Ioannidou, Ongena, and Peydro, 2015; Andonov, Bauer, and Cremers, 2017; Di Maggio and Kacperczyk, 2017). This behavior is attributed to institutional frictions and agency problems specific to these investors (see Campbell and Sigalov, 2022 for a discussion). For corporate DB pension plans, funding pressure arising from changes in the discount rate of pension liabilities is identified as a key friction.

While the literature provides robust evidence that low interest rates incentivize riskier investments, it is largely silent on how these incentives might be mitigated once they arise. Our paper fills this gap by examining how a regulatory reform designed to ease funding pressure on

[1] Lower interest rates increase the present value of pension liabilities, worsening a plan's funding ratio. Since pension liabilities typically have a longer duration than pension assets, they exhibit greater sensitivity to interest rate movements, creating a positive relationship between interest rates and DB plan funding ratios.

U.S. corporate DB plans influenced their investment behavior. We study the Moving Ahead for Progress in the 21st Century Act (MAP-21), a 2012 reform that boosted regulatory funding ratios and reduced their sensitivity to interest rate changes. We show that by lowering and stabilizing mandatory pension contributions, MAP-21 significantly reduced DB plans' incentives to invest in riskier asset classes. Our findings demonstrate that a relaxation of regulatory funding pressure can curb incentives to take asset risk, even without changing the underlying economic value of pension liabilities or financial reporting. The observed de-risking response is consistent with theoretical predictions and offers insights into the underlying frictions driving their behavior.

Aggregate industry patterns are consistent with the view that low interest rates increase funding pressure and push DB pension plans toward riskier asset allocations. Using pension plan data from the 1990s onward, we document that the positive relationship between U.S. corporate DB plans' funding status and equity shares, documented in Rauh (2009), weakens and eventually reverses in more recent years, as many plans become severely underfunded. While suggestive, these results are difficult to interpret causally and remain open to alternative explanations.

Identifying how funding pressure shapes DB plans' risk-taking is challenging, as interest rates are endogenous to economic conditions and affect both funding ratios and expected asset returns. For example, while lower interest rates increase funding pressure by raising the actuarial value of pension liabilities, they may also raise the excess return on riskier assets like equities relative to safer options such as investment-grade bonds (see, e.g., Bernanke and Kuttner, 2005). This makes it difficult to distinguish empirically whether shifts from bonds to equity investments are driven by higher risk-taking or higher equity returns (Calvet, Campbell, and Sodini, 2009).

MAP-21 provides an ideal setting for empirical identification by introducing unexpected and plausibly exogenous variation in the funding ratios of individual plans at a time when many plans were underfunded (i.e., when risk-taking incentives are likely at play). Originally a transportation bill, MAP-21 revised the discount rate methodology used to calculate the pension liabilities of U.S. corporate DB plans by extending the trailing average of corporate bond yields from two years to 25 years. In the low-rate environment at the time, this change raised the discount rate applied to pension liabilities, artificially improving regulatory funding ratios and shifting the funding distribution to the right. As a result, the median funding ratio rose from 80% in 2011 to 96% in 2012, leading to a 46% reduction in mandatory pension contributions.

This revised discount rate methodology, which represented a major change in the computation of pension liabilities, was added to MAP-21 in March 2012, just three months before the bill's passage as a revenue-generating measure (Dambra, 2018).[2] With funding secured, the bill advanced rapidly through the House and Senate in April and was signed into law in July, effective immediately. This expedited and somewhat unorthodox process gave pension stakeholders little time to anticipate or influence the reform. While the provision may also have aimed to provide relief to the sector, its effect on individual plans was plausibly exogenous: it is unlikely that a DB plan could foresee or tailor the revised discount rate methodology to its own circumstances.

Crucially, MAP-21's impact on funding ratios was heterogeneous across plans, reflecting predetermined differences in the maturity of pension liabilities.[3] As a result, plans with very similar initial funding deficits and other characteristics experienced different increases in regulatory funding ratios following the reform. Our identification strategy exploits this heterogeneity in "treatment intensity" to examine how comparable underfunded plans adjusted their asset allocations as MAP-21 improved their funding ratios to different degrees. In theory, as funding ratios rise toward full funding, incentives to invest in riskier asset classes in search of yield should weaken, with stronger de-risking responses predicted for plans receiving greater funding relief (Siegmann, 2007; Love, Smith, and Wilcox, 2011; Dyachenko, Ley, Rieger, and Wagner, 2022).

To bring this key prediction to the data, we adopt a difference-in-differences (DiD) framework and focus on plans with initial funding ratios between 80% and 85%. This captures a large mass of plans that, prior to MAP-21, were "bunching" just above the 80% regulatory threshold.[4] As

[2]See the Congressional Budget Office discussion of the implications of the revised discount rates for corporate tax revenues: https://www.cbo.gov/sites/default/files/cbofiles/attachments/hr4348conference.pdf.

[3]Because interest rates were at historically low levels at the time, the longer averaging period led to a greater increase in discount rates for liabilities with shorter maturities. In January 2012, discount rates rose by 3.56 percentage points for liabilities maturing in 0–5 years, compared to 1.78 and 1.33 percentage points for maturities of 6–20 years and over 20 years, respectively (see: https://www.irs.gov/pub/irs-drop/n-12-55.pdf).

[4]When a plan's funding ratio falls below 80%, sponsor costs increase sharply: mandatory contributions must be amortized over two years instead of seven, carryover balances cannot be used, and plans may be classi-

we document, bunching at 80% became especially pronounced following the Federal Reserve's post-2009 interest rate cuts. In 2011, the year preceding MAP-21, nearly half of the plans in our sample clustered just above this cutoff, reflecting severe funding pressure and strong incentives to avoid falling below 80%, which would have triggered discontinuously higher costs.

Focusing on this group offers several important advantages. First, all plans lie within a narrow funding range and therefore have very similar initial funding deficits. Second, all plans are "bunchers". Because bunching is a choice and is often viewed as a signal of strategic behavior, these plans likely differ from non-bunching plans in salient characteristics.[5] Hence, focusing on bunchers helps ensure more comparable treatment and control groups. Because bunching at this threshold was so widespread at that time, concentrating on this group enhances internal validity, while still capturing the behavior of a substantial share of DB plans in the sample.

For our baseline DiD analysis, we compare bunching plans that experienced above-median increases in funding ratios from MAP-21 (treatment group) with those that experienced below-median increases (control group). On average, plans in the treatment group saw a 42.3 basis point larger increase in discount rates and a 4.7 percentage point greater rise in regulatory funding ratios. The average funding ratio of treated plans increased from 81% prior to MAP-21 to 98.9% afterward, bringing them close to full funding, while the control group experienced a more modest increase from 81% to 94.2%. Importantly, prior to MAP-21 the two groups displayed strong parallel trends in asset allocations (i.e., in the shares of assets invested in the major asset classes).

In line with theoretical predictions, we find that plans experiencing larger increases in their funding ratios from MAP-21 reduced their equity allocations by more than those receiving smaller

fied as "at risk", triggering additional restrictions. Despite the substantial deficit implied by an 80% funding ratio, rating agencies and the media often treat this threshold as a dividing line between "healthy" and "unhealthy" plans (see, e.g., "The 80% Pension Standard Myth," American Academy of Actuaries, July 2012, https://www.actuary.org/sites/default/files/files/80_Percent_Funding_IB_071912.pdf).

[5]Across accounting, economics, and finance, bunching at regulatory thresholds is widely linked to strategic behavior aimed at avoiding costly rules or "managing" reported outcomes. Examples include education (Urquiola and Verhoogen, 2009), medicine (Barreca, Guldi, Lindo, and Waddell, 2011), government budgeting (Liebman and Mahoney, 2017), taxation (Saez, 2010), earnings management (Burgstahler and Dichev, 1997; Leuz, Nanda, and Wysocki, 2003; Bergstresser, Desai, and Rauh, 2006; Goncharov, Ioannidou, and Schmalz, 2023), and mortgages (Garmaise, 2015). Plans bunching at 80% are therefore natural candidates for examining strategic risk-taking and risk-shifting behavior.

relief. The magnitude of the effect is economically meaningful: a one percentage point increase in funding relief is associated with a 0.31 percentage point reduction in the share of assets invested in equities. Corresponding DiD specifications for other asset classes show a reallocation toward investment-grade bonds, consistent with a shift toward safer, liability-matching assets.[6] Dynamic DiD estimates show that this adjustment occurred in 2012, when MAP-21 took effect, with no evidence of differential pre-trends between treatment and control groups.

Additional results shed light on the economic mechanisms underlying the baseline treatment effect. Consistent with models in which financially constrained firms have stronger incentives to take risk when funding pressure is high (Love et al., 2011), we find that de-risking following MAP-21 is more pronounced among plans sponsored by highly levered firms with high default probabilities and among non-frozen plans, for which ongoing funding pressures are more salient. This suggests that elevated pre-reform equity exposure was at least partly driven by risk-shifting incentives, which weaken once funding pressure is exogenously relaxed. In line with models emphasizing aversion to funding shortfalls (Siegmann, 2007) or non-linearities in mandatory contributions (Dyachenko et al., 2022), reductions in equity exposure attenuate as plans' funding ratios approach, or slightly exceed, full funding, consistent with a non-linear response to the funding relief. We also find no significant heterogeneity in treatment effects with respect to Tobin's Q or dividend payout ratios, suggesting a limited role for sponsor growth opportunities and dividend policy in shaping pension risk-taking when funding pressure was binding.

We subjected our main findings to several robustness checks. Our baseline analysis relies on equity shares, which capture changes in portfolio composition arising from both active rebalancing—the behavior of interest—and valuation effects driven by market returns. Although the strong parallel trends in asset shares prior to MAP-21 provide important reassurance, time-series variation in these shares may still partly reflect market price movements rather than deliberate portfolio rebalancing (Calvet et al., 2009). To address this concern and obtain more precise estimates, we conduct a robustness test using return-adjusted asset shares that approximate portfolio

[6]The long-term nature of pension liabilities naturally favors long-duration fixed-income securities—such as government bonds—over more volatile equities (Campbell and Viceira, 2002; Sharpe and Tint, 1990).

weights net of benchmark index returns. The corresponding DiD estimates strengthen modestly. In addition, we verify that assignment into treatment and control groups does not correlate with latent plan or sponsor characteristics that bias our DiD estimates. In particular, we confirm that treatment intensity does not correlate with differences in baseline risk preferences, as proxied by differences in historical asset allocations, and that our results remain robust when re-estimating our baseline models using propensity score matching.

We also consider and rule-out several alternative interpretations. First, we find no evidence that the observed de-risking response reflects attempts to "lock in" higher MAP-21 funding ratios to facilitate insurance purchases. Changes in insurance coverage are similar across treatment and control groups. Second, we find no support for strategic efforts to avoid full funding—such as minimizing reversion taxes or limiting benefit increases—as drivers of the observed asset reallocation. Finally, we find that MAP-21 had real effects on contribution behavior: plans receiving greater funding relief reduced both mandatory and voluntary contributions, consistent with the reform easing regulatory funding pressure. Overall, these results reinforce the interpretation that the Post-MAP-21 de-risking reflects a relaxation in regulatory funding pressure rather than alternative motives related to insurance decisions or avoidance of full funding.

Our paper contributes to the large literature documenting how persistently low interest rates encourage financial intermediaries and institutional investors to shift toward riskier asset allocations in a reach for yield (e.g., Chodorow-Reich, 2014; Becker and Ivashina, 2015; Ioannidou et al., 2015; Di Maggio and Kacperczyk, 2017; Andonov et al., 2017). We focus on U.S. corporate DB pension plans and study how funding pressure shapes their risk-taking incentives, building on the relevant theoretical literature (Siegmann, 2007; Love et al., 2011; Dyachenko et al., 2022).[7]

While earlier work shows that better-funded plans historically held riskier portfolios (Rauh, 2009), we document that this relationship weakened and eventually reversed after the GFC as

[7] Coimbra, Gomes, Michaelides, and Shen (2025) shows that the asset allocation of DB pension funds has important asset-pricing and risk-sharing implications. There is also a related work on U.S. public DB plans, which operate under a very different governance and regulatory framework. A key distinction is that public plan discount rates are based on expected asset returns, which can directly incentivize risk-taking to justify higher discount rates (see, e.g., Andonov et al., 2017; Novy-Marx and Rauh, 2009; Novy-Marx and Rauh, 2011; Brown and Wilcox, 2009; Wilcox, 2006).

many plans became deeply underfunded. This reversal aligns with models that predict that the relationship between funding ratios and optimal equity exposure is non-linear, turning from positive to negative as plans fall below full funding (Siegmann, 2007; Dyachenko et al., 2022).

A key contribution of our paper is to show that targeted regulatory relief can curb incentives to increase exposure to risky assets. Exploiting plausibly exogenous and heterogeneous variation in funding relief from MAP-21, we provide causal evidence that easing regulatory funding pressure leads pension plans to de-risk their portfolios, even though the reform did not alter the economic value of pension liabilities or financial reporting; funding ratios under U.S. GAAP continued to be based on market interest rates and showed substantial deficits. Beyond documenting the average effect, we show how the de-risking response varied in the size of the funding relief and key sponsor characteristics, offering insights into the underlying frictions driving risk-taking.

Our findings highlight the importance of regulatory design in shaping institutional risk-taking and are particularly important given concerns that excessive risk-taking by underfunded institutions can amplify systemic vulnerabilities, as illustrated by episodes such as the U.S. Savings and Loan (S&L) crisis. In related work, Dambra (2018) shows that MAP-21 affected firms' cash holdings and payout policies by easing funding obligations. We complement this evidence by showing that MAP-21 also reshaped incentives to invest in riskier asset classes in search of yield.

Finally, our paper contributes to the literature on manipulation and strategic behavior in DB pension plans. Prior work shows that firms adjust actuarial assumptions and pension risk exposures in response to funding constraints and managerial incentives (Anantharaman, 2017; Comprix and Muller, 2011; Bergstresser et al., 2006; Michaelides, Milidonis, and Papakyriakou, 2025; Stefanescu, Wang, Xie, and Yang, 2018). We show that by easing regulatory funding pressure, MAP-21 reduces incentives for such behavior, consistent with the view that manipulation arises when binding funding constraints interact with strategic motives.

## 2 Institutional Framework and Testable Hypotheses

In this section we summarize the institutional and regulatory framework that governs US corporate DB pension plans, the changes brought about by MAP-21, and our testable hypotheses.

### 2.1 Institutional Framework Governing US Corporate DB Plans

To analyze the risk-taking incentives of U.S. corporate DB plans, it is essential to understand the financial and regulatory obligations these plans create for sponsor firms. A corporate DB plan is essentially an employer-sponsored retirement arrangement that guarantees specific benefits to employees, typically in the form of annuity payments based on factors such as the employee's tenure, salary history, and other plan parameters. The sponsor bears full responsibility for funding the plan and managing the associated investment risks through contributions and asset allocation decisions.[8] The prevailing assumption in the literature and in our analysis is that sponsor firms exercise substantial control over the investment strategy of their DB plans (Cocco, 2014).

The plan's liabilities equal the present value of future payments owed to its participants. These obligations, which represent debt of the sponsor firm, can be substantial. For example, Shivdasani and Stefanescu (2010) estimate that including pension assets and liabilities increases sponsor firms' leverage ratios by approximately 35%.[9] The plan's assets comprise prior contributions, investment gains or losses, and benefit payouts. Economically, the plan's assets belong to the sponsor firms' shareholders but are "encumbered" by the plan's obligations, with any residual gains or losses from the portfolio of assets flowing to the sponsors' shareholders (Merton, 2006).

A plan's regulatory funding ratio is measured by the Funding Target Attainment Percentage (FTAP), the ratio of pension assets to pension liabilities as defined under the Employee Retirement Income Security Act (ERISA). A ratio below 100% indicates underfunding. Funding levels can fluctuate due to changes in asset returns, market conditions, and the discount rates used to calculate the projected benefit obligations. Changes in actuarial assumptions, such as those examined in

[8] By contrast, DC plans shift these risks and responsibilities to employees.

[9] A variance decomposition analysis shows that pension liabilities are a significant element of the time-invariant factors of corporate capital structure (Lemmon, Roberts, and Zender, 2008). Uncertainty in the valuation of DB pension liabilities is a significant source of risk for potential acquirers and a takeover deterrent (Cocco and Volpin, 2013).

this paper, can generate substantial volatility in projected pension liabilities and funding ratios.

Under ERISA, funding deficits must be covered with additional mandatory contributions.[10] Since the 2006 Pension Protection Act, deficits must be amortized over a seven-year period, down from the previous 30-year window. Importantly, if a plan's FTAP falls below 80%, sponsors face a discontinuous increase in costs. Mandatory contributions to cover pension deficits are based on an accelerated two-year amortization schedule instead of seven years. In addition, plans that fall below this threshold may be classified as "at risk" and face additional restrictions, including limits on benefit improvements and lump-sum payments to retirees. Notably, the 80% threshold is also often (misleadingly) used by media and rating agencies as a dividing line between "healthy" and "unhealthy" plans.[11] Because of these discontinuously higher costs, as funding pressure increases plans and sponsors may have strong incentives to bunch just above the 80% threshold.

The Pension Benefit Guaranty Corporation (PBGC), a federal agency, provides partial insurance to employees against sponsor default. The insurance premiums include a flat-rate charge per participant and a variable-rate component tied to a plan's unfunded vested benefits. However, the premiums are only partially risk-based: they do not adjust for sponsor default probabilities, asset allocation risk, or the likelihood of distress-induced plan termination, and the amounts charged for funding deficits are relatively low.[12] As a result, the PBGC guarantee functions as a put option on the plan's assets (Merton, 1977). Sponsors seeking to maximize the value of this option may increase pension deficits and asset risk, transferring wealth to shareholders (Love et al., 2011).

## 2.2 Motivating Evidence and Hypothesis Development

**Prior to MAP-21** To assess the potential impact of MAP-21 on corporate DB plans, it is useful to first understand the economic and regulatory environment preceding its enactment.

[10]Minimum required contributions include the plan's normal cost, i.e., the present value of benefits accrued in the current year—and amortization payments for any funding deficit.

[11]See related discussions in "The 80% Pension Standard Myth," American Academy of Actuaries (July 2012), available at: https://www.actuary.org/sites/default/files/files/80_Percent_Funding_IB_071912.pdf or the post-conference brief *"Pathways to LDI"* by the Head of Defined Benefit Actuarial at MassMutual, available at: https://crain-platform-cpi-prod.s3.amazonaws.com/2019-11/MassMutual_PostConference%20Brief_11.11.pdf.

[12]In 2011, the median PBGC premium represented just 0.15% of pension assets and 2.33% of sponsor firms' annual pension contributions.

In the aftermath of the GFC, an extended period of exceptionally low interest rates placed DB pension plans under severe funding pressure. At the time, the discount rates used to value pension liabilities were based on two-year trailing averages of yields on investment-grade corporate bonds. Consequently, when in 2009 the federal funds rate (FFR) was reduced and maintained close to 0% for an extended period, discount rates fell sharply, raising the actuarial value of pension liabilities and lowering funding ratios. As shown in Figure 1, between 2007 and 2011 the median FTAP declined from 92% to 80%. This positive relationship between the regulatory funding ratio and monetary policy rates also holds for a longer horizon since the 1990s. As shown in Table 1, pension liabilities, which generally have a longer duration than pension assets, exhibit a stronger negative relationship with the FFR, resulting in an overall positive relationship between funding ratios and policy rates.[13] (Table A1 in the Appendix provides definitions for all variables.)

As funding levels declined, the FTAP distribution began to shift to the left, and an increasing number of plans began to bunch just above the 80% threshold (Figure 2).[14] The Pension Protection Act of 2006 may have intensified pressure on sponsor firms. By reducing the amortization period for addressing funding deficits from 30 years to 7 years, it imposed stricter and more immediate financial obligations on sponsors. Although intended to strengthen plan funding, these requirements, combined with ultra-low rates, may have inadvertently encouraged sponsors to tolerate larger deficits and pursue riskier asset allocations to ease cash flow constraints.

**MAP-21 Pension Relief and Testable Hypotheses** Against this backdrop, MAP-21, enacted on July 6, 2012 with immediate effect, provided an unexpected and possibly exogenous funding relief to corporate DB plans. The reform extended the averaging window used to calculate the regulatory discount rates of pension liabilities from 2 to 25 years.[15] Given historically low interest rates prevailing at the time, the longer window raised the discount rates and, consequently,

[13]Similar results are observed using the shadow rate. For more information on shadow rates see Wu and Dora (2016).

[14]Because the impact of falling rates on liability valuations was smoothed over a two-year period, the full effect of the 2009 interest rate cut materialized in 2011, precisely when underfunding and bunching near the 80% threshold peaked.

[15]This extended averaging window applied only to the discounting of pension liabilities for regulatory funding calculations; all other valuations continued to be based on unadjusted market rates. Although plans were permitted to delay the adoption of MAP-21 rates until 2013, the vast majority in our sample (93.4%) implemented them in 2012 to benefit from reduced contribution requirements (Kisser, Kiff, and Soto, 2017).

reduced the present values of pension liabilities. The impact was immediate and substantial.

As shown in Figure 1, the median FTAP rose from 80% in 2011 to 96% in 2012. Figure 3 documents a marked rightward shift in the FTAP distribution across plans, highlighting the broad reach of the relief. Sponsor firms' mandatory contributions to their pension funds fell by 46%. This sharp improvement in funding positions constituted an unexpected positive wealth shock for shareholders of firms sponsoring underfunded plans, consistent with the significant positive abnormal returns around MAP-21's announcement documented by Dambra (2018).

MAP-21 offers a compelling setting for causal identification. MAP-21 was initially introduced as a transportation bill on November 7, 2011 and quickly gained bipartisan support due to urgency to secure infrastructure funding. The pension provisions were added late in the legislative process as a revenue-raising measure after lawmakers faced an unexpected funding shortfall (Dambra, 2018). By increasing the actuarial discount rates used for regulatory purposes, MAP-21 reduced tax-deductible pension contributions and thereby increased near-term taxable corporate income. With funding secured, the bill advanced quickly through the House and Senate on April 18 and April 24, 2012, respectively, and was signed into law on July 6, 2012, with immediate effect.

This expedited legislative process, completed in under a year, gave pension stakeholders limited time to anticipate or influence the outcome. Moreover, the process marked a departure from standard practice: pension funding rules are typically revised through dedicated pension legislation. In addition, the specific changes, which represented a significant departure from previous standards, were difficult to predict. As a result, MAP-21 generated unexpected and plausibly exogenous variation in the regulatory funding ratios of individual plans.

Importantly, the impact of the new discount rates was heterogeneous. Because of the historically low interest rates prevailing at the time, the longer averaging window had a disproportionately larger effect on shorter-maturity liabilities.[16] As a result, plans with very similar

[16]Discount rates are calculated using trailing averages of investment-grade corporate bond yields over the previous 2 or 25 years, segmented into three maturity buckets : 0–5 years (segment 1), 6–20 years (segment 2), and over 20 years (segment 3). The extended averaging window from 2 to 25 years resulted in a 3.56 percentage point increase in the segment 1 discount rate, while segment 2 and segment 3 discount rates rose only by 1.78 and 1.33 percentage points, respectively. See https://www.irs.gov/pub/irs-drop/n-12-55.pdf.

initial deficits and other characteristics experienced different increases in funding ratios, driven by historical differences in liability structures and corporate bond yields over the prior 25 years.

We exploit this cross-sectional heterogeneity in "treatment intensity" within a DiD framework to examine how comparable underfunded plans near the 80% funding threshold adjusted their asset allocations as MAP-21 exogenously relaxed regulatory funding pressure. Models of portfolio optimization that incorporate key features of the U.S. institutional framework, such as mandatory contribution rules and PBGC premiums, predict that as an underfunded plan's funding ratio rises toward full funding, the optimal share of assets invested in equities declines (see, e.g., Siegmann, 2007; Love et al., 2011; Dyachenko et al., 2022). We thus expect similarly underfunded plans that experienced greater funding relief from MAP-21 (i.e., that get closer to full funding) to re-balance their portfolios more strongly toward safer asset classes. This leads to our first hypothesis:

**H1:** *All else equal, similarly underfunded plans that experienced greater relief from MAP-21 shift their portfolios away from riskier asset classes toward safer ones to a greater extent.*

Theory also suggests heterogeneity in the response to the funding relief. For example, models emphasizing risk-shifting motives arsing from under-priced pension insurance and limited liability predict that sponsor firms closer to default have stronger incentives to maintain large pension deficits and invest pension assets in riskier assets (Merton, 1977; Love et al., 2011). For such sponsors, higher portfolio risk increases the value of the implicit put provided by the PBGC, shifting downside risk to the insurer and plan participants. Under this mechanism, funding relief from MAP-21 should lead to a more pronounced reduction in risk-taking among plans sponsored by more financially constrained firms closer to default. This leads to our second hypothesis:

**H2:** *All else equal, the de-risking response to MAP-21 is more pronounced among plans sponsored by more financially constrained firms closer to default.*

Models in which risk-taking reflects aversion to regulatory funding shortfalls (Siegmann, 2007) or non-linearities in mandatory contributions (Dyachenko et al., 2022) predict that the relationship between funding ratios and equity exposure is non-linear, turning from negative to positive as funding ratios approach, or slightly exceed, full funding.[17] Under these motives, the de-risking response to MAP-21 may be non-linear in the magnitude of the relief, weakening as plans' funding ratios move toward, or slightly above, full funding. This leads to our third hypothesis:

**H3:** *The de-risking response to MAP-21 is non-linear in the magnitude of funding relief, with reductions in risky asset exposure attenuating as funding ratios approach, or slightly exceed, full funding.*

Although MAP-21 was formally introduced as a temporary measure, with provisions to phase out the higher discount rates beginning in 2013, the credibility of this rollback was limited. Neither firms nor the government had incentives to reinstate the original rules, as reversing the relief would have increased reported pension deficits and reduced government tax revenues. As discussed in Dambra (2018), congressional budget rules, such as the use of 10-year budget windows, create strong incentives to delay the reversal of nominally temporary provisions like MAP-21. Consistent with these incentives, subsequent legislation, including the Highway and Transportation Funding Act (HATFA) of 2013 and the American Rescue Plan of 2021, extended and ultimately expanded the funding relief originally introduced under MAP-21. Markets and sponsors appear to have anticipated this. As shown in Dambra (2018), MAP-21's announcement generated significant positive abnormal returns for firms sponsoring plans with large funding deficits, and firm managers used the resulting cash flow relief to increase share repurchases.

## 3 Data and Descriptive Analysis

Our data on U.S. corporate DB pension plans' operations, funding status, and asset allocations come from IRS Form 5500 filings, maintained and published by the U.S. Department of Labor (DOL) since 1984. Each year, all pension plan sponsors with at least 100 employees are required to file Form 5500, which comprises several schedules containing detailed information on plan characteristics, finances, and actuarial status. Reporting is mandatory and willful misreporting is

[17] See Figure 1 in Siegmann (2007) and Dyachenko et al. (2022). In Dyachenko et al. (2022), the relationship turns negative again for sufficiently well-funded plans, as sponsors optimally reduce risk when funding ratios move far above full funding. This upper tail is not empirically relevant in our setting: in our DiD sample, post-MAP-21 FTAP values range from 81% to 136%, with the vast majority of high-relief plans in the area between 100% and 110%.

subject to penalties. We complement these with sponsor-level financial data from Compustat.

To construct our sample, we combine information from the Form 5500 main filing and Schedules SB, H, and R for single-employer DB plans from 2009 to 2018. The main form allows us to identify DB plans and provides basic plan characteristics. Schedule SB contains actuarial information, which we use to measure each plan's funding status (FTAP). Schedule H provides financial information, including pension assets and sponsor contributions. Data on asset allocations, such as the shares of assets invested in equities, investment-grade bonds, high-yield bonds, real estate, and other categories, are taken from Schedule R, which has been available since 2009. Asset allocations are also available in Schedule H since 1984. However, due to a reporting relief, Schedule H does not include allocations on investment vehicles, such as Direct Filing Entities and Registered Investment Companies, which have become significant in recent years (e.g., Panis and Brien, 2015). We thus rely on asset allocations from Schedule R and start our sample period in 2009.

Our sample is restricted to single-employer DB plans, as MAP-21 applies only to these plans. We further require each plan to have at least five consecutive years of data, yielding an unbalanced panel of 2,791 unique plans. Some firms sponsor multiple plans. For example, in 2011, 33% of sponsor firms had multiple plans. Because funding requirements apply to each plan separately and pension assets and liabilities cannot be transferred from one plan to another, we retain all plans in the sample and conduct our empirical analysis at the pension plan level.[18]

Table 2 reports summary statistics. The average plan holds $670 million in assets and has a funding ratio of 97.3%. On average, equities account for 47% of pension assets and investment-grade bonds for 34.9%. Other asset classes, such as high-yield bonds, real estate, and residual categories, are less important, accounting for 3.5%, 2.3%, and 13.1% of assets, respectively.

Time-series patterns are consistent with our central thesis that, in the post-GFC period—when many plans became severely underfunded—risk-taking incentives intensified, and that MAP-21 subsequently mitigated these incentives. Historically, better-funded plans tended to hold riskier

[18]In robustness tests, we confirm that our main findings are robust to potential dependence across plans, either by excluding plans that share a common sponsor or by clustering standard errors at the sponsor-firm level (Internet Appendix Table IA1).

portfolios, consistent with the view that risk-management considerations dominated risk-taking motives (Rauh, 2009). However, as we show in Table 3, this positive relationship reversed in the post-GFC period: underfunded plans began allocating a larger share of assets to equities.[19] This reversal is consistent with Siegmann (2007) and Dyachenko et al. (2022), which show that the relationship between funding ratios and optimal equity exposure switches from positive to negative when plans fall into the underfunded region.

Figure 4 further illustrates the evolution of this relationship over time by plotting year-by-year regression coefficients alongside average FTAPs. The association between funding ratios and equity shares weakened steadily in the years leading up to the GFC, coinciding with a gradual decline in funding ratios over time, a pattern widely attributed to the secular decline in real interest rates over the preceding decades. From 2009 onward, the relationship turned significantly negative, as underfunded plans increasingly shifted toward riskier portfolios in response to the heightened funding pressure. Notably, in 2013—the year following the implementation of MAP-21—the negative relationship attenuated substantially, consistent with a reduction risk-taking incentives as MAP-21 relax funding pressure. A decline in the share of assets invested in equities after MAP-21 is also visible in aggregate asset allocation trends in Appendix Figure A1.

While clearly suggestive, these patterns do not permit causal inference, as interest rate changes are endogenous to economic conditions and jointly affect funding ratios and asset returns. In the next section, we describe how we leverage plausibly exogenous variation for causal inference.

# 4 Identification Strategy

Our goal is to examine how funding pressure shapes the risk-taking incentives of underfunded plans. For our baseline tests, we focus on plans with 2011-FTAPs between 80% and 85%, which we refer to as bunchers. This choice is driven by internal validity concerns. Bunching often reflects efforts to exploit regulatory and commonly used thresholds to evade regulations or manipulate outcomes, making these plans prime suspects for risk-shifting behavior. Prior literature cautions

[19] This result also holds in a constant sample of plans, ruling out compositional changes as a driver (Internet Appendix Table IA2). Unconditional trends similarly show a sharp rise in equity allocations (Internet Appendix Figure IA1).

against pooling bunchers with non-bunchers together, as these groups may differ systematically in unobservable ways (see, e.g., Bakke and Whited, 2012).

Figure 5 indicates that many plans were actively targeting the 80% funding threshold in 2011. Panel A shows a pronounced spike in the distribution of FTAPs just above 80%, with 44% of plans bunching in this area. The McCrary (2008) test, reported in Panel A, confirms that the discontinuity at 80% is statistically significant at the 1% level.[20] Panel B further shows that plans just above 80% made discontinuously larger voluntary contributions than plans just below the threshold, indicating that sponsors actively used contributions to manage funding ratios and avoid regulatory penalties.[21] These patterns suggest that bunching plans may be systematically different from those that do not engage in such behavior. Appendix Table A2 further confirms this intuition. Relative to plans with FTAPs in the [70,80%) range, bunchers are sponsored by larger and less financially constrained firms, consistent with a greater ability to make additional contributions to remain above 80%. However, compared with fully funded plans (FTAPs in [100,150%]), sponsors of bunching plans are more leveraged and exhibit higher default risk, as reflected in lower Altman Z-scores, characteristics associated with stronger risk-taking and risk-shifting incentives.

These differences underscore the importance of focusing on bunchers. By restricting the sample to a narrow window just above the 80% threshold, we mitigate confounding differences and improve the comparability of treatment and control groups. Within this sample, we employ a DiD framework to examine how plans with similar initial funding ratios adjusted their asset allocations as MAP-21 relaxed funding pressure to differing degrees. As discussed earlier, in the low-interest-rate environment prevailing at the time, the extension of the discount rate averaging window from 2 to 25 years had a disproportionately large effect on shorter-maturity liabilities. Consequently, plans with very similar initial deficits and other observable characteristics experienced differential increases in funding ratios, driven by predetermined differences in liability structures and historical corporate bond yields over the preceding 25 years.

[20]Figure 5 also shows milder bunching at other regulatory thresholds (e.g., 90% and 100%), consistent with the presence of weaker penalties below those cutoffs.

[21]To manage their FTAPs and hit critical regulatory thresholds, Dambra (2018) finds that they also likely exploit accounting flexibility through actuarial assumptions and methodological changes.

We measure the funding relief by the increase in their funding ratios between 2011 and 2012. To isolate the impact of liability changes, while holding asset values constant, we define funding relief using 2011 asset values, prior to any portfolio re-balancing, as follows:

$$\text{Funding Pressure Relief}_{\text{i}} = \text{Assets}_{i,2011}/\text{Liabilities}_{i,2012} - \text{Assets}_{i,2011}/\text{Liabilities}_{i,2011}. \quad (1)$$

For our baseline analysis, we compare bunchers with Funding Pressure Relief$_i$ values above the median (treatment group) with those below the median (control group).[22] To bring our first hypothesis (Hypothesis 1) to the data, we estimate the following specification:

$$y_{i,t} = \beta_0 + \beta_1 \cdot \text{High-Relief}_i \times \text{Post}_t + \mu_i + v_{j,t} + \epsilon_{i,t}, \quad (2)$$

where $i$ indexes pension plans, $j$ indexes the sponsor's industry, and $t$ indexes years. The dependent variable $y_{i,t}$ indicates the share of the assets of plan $i$ invested in equities in year $t$. We also estimate corresponding specifications for other asset classes using the shares of plan assets in each of the other classes. The variable High-Relief$_i$ equals one if the plan's Funding Pressure Relief$_i$ (Equation (1)) is above the median and zero otherwise. Post$_t$ equals one after the implementation of MAP-21 and zero otherwise. We use an event window of three years before and three years after MAP-21, excluding the year of its introduction (i.e., 2009-2015, excluding 2012). The asset allocation data are from Schedule R and are measured at the beginning of a plan year.

To control for the time-invariant characteristics of pension plans and their sponsors, we include pension plan fixed effects, $\mu_i$. In addition, we include industry-year fixed effects, $v_{j,t}$, to further account for time-varying economic shocks that are specific to the sponsor firm's industry, based on the 3-digit NAICS code of the sponsor firms. The model is estimated using OLS, with standard errors corrected for heteroskedasticity and clustered at the pension plan level.[23]

Hypothesis 1 predicts that the treatment group, which experienced a greater funding relief under MAP-21, shifts away from equities towards safer assets to a greater extent than the control

[22]While we cannot entirely rule out the possibility that our measure captures additional changes in pension liabilities triggered by MAP-21, our robustness analysis examines the potential role of insurance purchases, pension risk transfers, pension freezes, and changes in PBGC premiums. We also consider an alternative measure of funding relief based on changes in mandatory contributions following MAP-21. Our main results are qualitatively unchanged.

[23]In robustness tests, we show that results are robust to clustering standard errors at the sponsor firm-level (Internet Appendix Table IA1).

group. This predicts that $\beta_1$ will be negative and statistically significant for the equity share, and positive and statistically significant for safer asset classes such as investment-grade bonds.

**Internal Validity** Several pieces of evidence support the internal validity of our DiD specification. First, Table 4 shows that the two groups experienced meaningful differences in treatment intensity.[24] On average, the treatment group experienced a 42.3 basis points larger increase in its discount rate and a 4.66 percentage points larger increase in its funding ratio. Second, Figure 6 shows the average equity shares of the two groups from 2009 to 2015. Before MAP-21, the average equity shares of both groups moved in parallel and their equity shares were nearly identical.[25] Third, Table 5 shows that the two groups are similar across a range of plan- and sponsor-level characteristics. In most cases, differences are not only statistically insignificant but also economically negligible. The only notable exceptions are sponsor size, plan frozen status, and the share of active employees. To account for these imbalances, our baseline specification includes plan fixed effects, as these characteristics are largely time-invariant over our short event window. In robustness checks, we confirm that our findings are unchanged when applying propensity score matching based on sponsor size, frozen status, and the share of active employees.

To bring our second and third hypotheses to the data, we extend the baseline DiD specification in Equation (2). In particular, we assess the risk-shifting hypothesis by interacting $\text{High-Relief}_i \times \text{Post}_t$ with plan- and sponsor-level characteristics related to financial constraints and default risk. To examine non-linear responses to the funding relief, we further extend the baseline design by partitioning bunching plans into finer groups based on the magnitude of $\text{Funding Pressure Relief}_i$, allowing treatment effects to vary across levels of funding relief (using 7 groups instead of 2).

[24]The effective discount rate is the interest rate used to calculate the present value of pension liabilities, as reported in Line 5 in Schedule SB of the IRS 5500 forms.

[25]In robustness analysis, we further validate the parallel trends assumption using dynamic DiD specifications of Equation (2) and confirm parallel pre-trends for all other major asset classes.

# 5 Empirical Results

This section presents our empirical findings. We report results for the three hypotheses, along with robustness analyses and additional evidence on the underlying mechanism, alternative explanations, and outcomes beyond asset allocations.

## 5.1 Baseline Results

We begin by examining whether funding relief from MAP-21 led underfunded plans to reduce their exposure to risky assets (Hypothesis 1). We estimate Equation (2) for plans with 2011 FTAPs in the [80%, 85%] range (bunchers), exploiting cross-sectional variation in treatment intensity generated by MAP-21.[26] Table 6 reports the results. Column (1) shows that the DiD coefficient $\beta_1$ for equity holdings is negative and statistically significant at the 1% level, indicating that plans experiencing greater funding relief reduced their equity allocations more than plans receiving less relief. The estimated coefficient of –2.813 implies that, following MAP-21, high-relief plans reduced their equity share by 2.8 percentage points more than low-relief plans. Relative to the pre-MAP-21 mean equity share of 50.82%, this corresponds to a decline of 5.5% (-2.81/50.82).

Scaling the estimate by the average difference in funding relief between the two groups (9.03 percentage points), the results imply that a 1 percentage point increase in funding relief is associated with a 0.31 percentage point reduction in equity exposure. For the average plan in our sample, with $680 million in assets, this translates into a reallocation of roughly $19.1 million away from equities. While economically meaningful at the plan level, this rebalancing is unlikely to have affected asset prices in aggregate. Across all plans in the sample, which held $713 billion in assets in 2011, the implied reduction in equity holdings is approximately $20 billion, or about 0.11% of total U.S. equity market capitalization, which stood at $17.9 trillion at the end of 2011.

To further examine how plans reallocated their portfolios following reductions in equity exposure, we estimate analogous DiD specifications for the other major asset classes (Columns (2)–(5) of Table 6). The results indicate that plans primarily shifted toward investment-grade bonds, the

[26]Results are robust to using narrower FTAP windows around the 80% threshold (Internet Appendix Table IA3).

safest asset class. The DiD coefficient in Column (2) is positive and statistically significant at the 1% level, indicating that the treatment group increased its allocation to investment-grade bonds by 2.614 percentage points more than the control group. We also observe a modest decline in real estate holdings (–0.412 percentage points), which is marginally significant at the 10% level. In contrast, the coefficients for other asset classes are small and statistically insignificant.

To inspect the full dynamics, we also estimate corresponding dynamic DiD specifications. Figure 7 plots the estimated coefficients for equity allocations and shows that the treatment effect emerges only after the implementation of MAP-21, with no evidence of differential pre-trends between the treatment and control groups. We observe the same pattern for all other major asset classes (Internet Appendix Figure IA2). These results support the parallel trends assumption and reinforce the interpretation that the baseline findings reflect portfolio rebalancing induced by MAP-21 rather than pre-existing differences in asset allocations related to latent risk preferences.[27]

Overall, these results provide strong support for Hypothesis 1 and are consistent with models in which regulatory funding deficits incentivize riskier asset allocations. As MAP-21 exogenously relaxed regulatory funding pressure, plans reduced their exposure to risky assets and reallocated primarily toward the safest asset class. This suggests that, when regulatory funding constraints were binding, similarly underfunded plans held riskier portfolios than they would have in the absence of such pressure. Before turning to analyses that shed further light into the motives driving this behavior, we first subject our baseline results to a series of robustness checks.

**Robustness Checks** First, we implement propensity score matching. To construct more comparable treatment and control groups, we match on key plan characteristics such as sponsor size, frozen status, and share of active employees. Despite the resulting reduction in sample size, the DiD estimates obtained from the matched sample are very similar to the baseline estimates (Appendix Table A4). As can be further observed in Internet Appendix Table IA4, the matching

[27]Appendix Table A3 further shows that our treatment-intensity measure, High-Relief$_i$, is unrelated to pre-reform portfolio conservativeness. We classify a plan as conservative if its average equity share is below the sample median, using either allocations from the immediate pre-MAP-21 period (2009–2010) or from an earlier window (2000–2007). Across both measures, treatment intensity does not correlate with conservative investment behavior, alleviating concerns that differences in latent risk preferences between treatment and control groups drive our results.

procedure successfully eliminated the few significant differences between the two groups.

Second, we consider an alternative measure of funding relief, based on changes in mandatory contributions following MAP-21 instead of our measure based on Equation (1). Intuitively, larger reductions in mandatory contributions correspond to greater funding relief. As shown in Column (2) of Appendix Table A5, our main finding (the decline in equity allocations for plans receiving a greater funding relief) is robust to this alternative measure, although the statistically significance is somewhat weaker (10% level). A potential limitation of this alternative measure is that changes in mandatory contributions can arise from changes in both assets and liabilities, making it harder to isolate the liability-side channel that we aim to capture. By contrast, our baseline measure holds assets constant, capturing variation from purely liability-side adjustments between 2011 and 2012.

Third, we estimate our baseline models using alternative dependent variables. A potential concern is that changes in asset shares may partly reflect passive valuation effects rather than active rebalancing (Calvet et al., 2009). To address this concern, we construct return-adjusted portfolio shares that remove the component of asset growth attributable to market performance.[28] Re-estimating our DiD specification with these adjusted shares yields results very similar to the baseline findings (Appendix Table A6). If anything, the estimated effects are slightly stronger. The DiD coefficient in column (1) equals −3.601 (vs. −2.813 in the baseline), corresponding to a semi-elasticity of −0.39 (i.e., −3.601/9.03) compared to −0.31 in the baseline specification.

### 5.2 Economic Mechanism

To shed light on the underlying economic mechanisms driving the bunchers' behavior, we first examine the heterogeneity in our baseline treatment estimates with respect to key plan and sponsor characteristics. Models emphasizing risk-shifting motives predict that financially constrained firms close to default have stronger incentives to invest in riskier asset allocations when funding pressure is high (Love et al., 2011). Under this mechanism, plans sponsored by such firms should de-risk more once MAP-21 exogenously releases funding pressure (Hypothesis 2).

[28]Because individual security holdings are not observed, we proxy asset-class returns using standard benchmarks (e.g., the S&P 500 for equities) and subtract the implied capital gains from reported end-of-year asset values before recomputing portfolio shares following an approach similar to Sirri and Tufano (1998).

We test this prediction by augmenting Equation (2) as follows:

$$
\begin{aligned}
y_{i,t} = \beta_0 + \beta_1 \cdot \text{High-Relief}_i \times \text{Post}_t + \beta_2 \cdot \text{High-Relief}_i \times \text{Post}_t \times Z_{i,2011} \\
+ \beta_3 \cdot \text{Post}_t \times Z_{i,2011} + \mu_i + v_{j,t} + \epsilon_{i,t},
\end{aligned} \tag{3}
$$

where $Z_{i,2011}$ captures pension-plan or sponsor characteristics measured before MAP-21.

We begin with the variables most closely tied to financial distress: sponsor leverage and the probability of default, measured by the Altman Z-score. Each variable is coded as an indicator equal to one for firms with above-median leverage or below-median Z-scores in 2011, so that the indicator captures greater default risk. In our sample, plans with above-median default probability have an average Z-score of 1.88, just above the commonly used distress threshold of 1.81.

The results are reported in columns (1) and (2) of Table 7. In line with Hypothesis 2, we find that high-relief plans sponsored by more levered firms or firms with higher default probabilities reduce equity exposure significantly more as MAP-21 releases funding pressure.[29] Further in column (3), we consider whether de-risking is weaker in settings where ex ante incentives to take risk is limited. A natural candidate is frozen plans. Because these plans no longer admit new participants and ceased accruing additional benefits ("hard freezes"), ongoing funding pressure is lower.[30] All else equal, we therefore expect these plans to exhibit a smaller shift away from risky assets when MAP-21 provides exogenous funding relief. Consistent with this prediction, the interaction with $Frozen_{i,2011}$ carries the opposite sign of the baseline DiD effect, indicating a smaller post-MAP-21 decline in equity exposure. Finally, in columns (4) and (5) we examine whether other sponsor characteristics, such as growth opportunities or dividend payout policies, play a significant role. We find no evidence of systematic heterogeneity along these dimensions.

Overall, the heterogeneity in the treatment effect indicates that bunching plans' higher equity shares prior to MAP-21 were likely linked to risk-shifting rather than to alternative factors related to growth opportunities or dividend policies of sponsors. For firms with a significant probability of bankruptcy, maintaining substantial pension deficits and investing pension assets in riskier

[29]Internet Appendix Table IA5 further shows that heterogeneity is weaker along broader measures of financial pressure, including plan size, contribution burdens, and unionization.

[30]Rauh, Stefanescu, and Zeldes (2020) estimate that freezing DB plans reduces future payroll costs by about 13%, with most of the savings remaining after higher DC contributions.

asset classes can be value-maximizing because large gains can reduce shortfalls, while large losses are likely to be absorbed by the PBGC. For financially healthy firms, such risk taking is undesirable, as any pension losses from riskier investments will likely be borne by the company itself.

We further examine whether the response to MAP-21 is non-linear in the size of the funding relief. Models in which risk-taking incentives are driven by aversion to funding deficits (Siegmann, 2007) or by non-linearities in mandatory contributions (Dyachenko et al., 2022) predict that the response to MAP-21 should attenuate as plans' funding ratios approach, or slightly exceed, full funding (Hypothesis 3). To bring this prediction to the data, we partition bunching plans into seven groups based on the size of their funding relief from MAP-21. Each group contains an equal number of plans with comparable initial funding deficits, with Group 1 experiencing the smallest funding relief and Group 7 the largest. We then estimate the following modified DiD specification:

$$\text{Equity}_{i,t} = \alpha + \sum_{k=2}^{7} \beta_k \,\text{Relief Group}_{i,k} \times \text{Post}_t + \mu_i + v_{j,t} + \epsilon_{i,t}, \tag{4}$$

where Group 1 is the omitted group. The coefficients $\beta_k$ measure how much more (or less) plans in group $k$ adjust their equity exposure relative to the omitted group. For example, a negative $\beta_3$ indicates stronger de-risking in Group 3 than in Group 1. Figure 8 plots the coefficient estimates. Consistent with Hypothesis 3, the pattern exhibits an inverse hump shape, with the response peaking at Group 5, whose average post-reform funding ratio reaches 98.2%.

These results align closely with models of portfolio optimization in which aversion to funding shortfalls and non-linear contribution rules create incentives to invest in risky assets to mitigate funding deficits. They are also consistent with our earlier finding that the historically positive relation between funding ratios and the share of pension assets invested in risky assets reverses in the post-GFC period, when many plans face severe funding pressure from growing deficits.

### 5.3 Additional Outcomes and Alternative Explanations

In this final section, we examine how MAP-21 affected other outcomes, including pension contributions, the propensity to freeze plans, and insurance premiums. We also assess alternative explanations for our baseline findings, such as the possibility that plans reduced equity exposure to purchasing pension insurance or as part of a strategy to avoid becoming fully funded.

**Pension Contributions** We begin by examining how MAP-21's funding relief influenced sponsors' pension contributions. While a reduction in mandatory contributions is mechanical—higher funding ratios and smaller deficits directly lower required minimums—it is less obvious how voluntary contributions might respond. To examine the impact of MAP-21 on pension contributions, we estimate our baseline DiD specification using log total, mandatory, and voluntary contributions as alternative dependent variables. Results are reported in Table 8. Across all specifications, the coefficient on High-Relief × Post is negative and statistically significant, indicating that high-relief plans reduce contributions sharply relative to others after MAP-21. The estimates imply reductions of approximately 69% for total contributions, 76% for mandatory contributions, and 63% for voluntary contributions. The decline in voluntary contributions suggests that, once funding pressures eased, discretionary top-ups became less necessary or desirable.

**Pension Freezes** Next, we examine how MAP-21 affects incentives to shift risk to employees or insurers by freezing their DB plans. In recent years, many firms have frozen DB plans and moved to DC arrangements, which may improve the investment performance of pension plans, especially for small DB plans (Jang and Wu, 2025).[31] However, this trend also raises important policy concerns, as employees often lack the expertise and resources to manage retirement risks without the expertise, pooling, and intertemporal smoothing of DB plans (Merton, 1983; Shiller, 1999).[32] Additionally, the growing use of individual annuity products has raised concerns that risk is merely being shifted from pension sponsors to the insurance sector (see, e.g., Ellul, Jotikasthira, Kartasheva, Lundblad, and Wagner, 2022; Klingler, Sundaresan, and Moran, 2025).

To test whether MAP-21 affected freezing behavior, we re-estimate Equation (2) using a binary

[31] Firms often cite employee demand for flexibility, rising healthcare costs, and volatility in interest rates and accounting rules as motivations for freezing DB plans (PricewaterhouseCoopers, 2014). These shifts reduce funding obligations and risk exposure.

[32] Research shows that employees often lack the financial literacy or engagement needed to manage DC portfolios effectively (Madrian and Shea, 2001; Agnew, Balduzzi, and Sundén, 2003; Sialm, Starks, and Zhang, 2015; Kronlund, Pool, Sialm, and Stefanescu, 2021).

indicator for plan freeze status as the dependent variable. Results are reported in Column (1) of Table 9. We find no statistically significant difference in freeze likelihood between plans receiving above- versus below-median MAP-21 relief. The estimated DiD coefficient (0.016) is small and statistically indistinguishable from zero. These findings suggest that, unlike asset allocation, MAP-21 had no meaningful impact on sponsors' decisions to freeze their DB plans.

**Insurance Premiums** Next, we examine whether changes in PBGC premiums following MAP-21 may contaminate our baseline estimates. To mitigate moral hazard created by the funding relief, MAP-21 raised insurance premiums. In practice, however, these changes translated into only minor movements in total premium payments for the typical plan.[33] Even if economically small, differential exposure of treatment and control plans to premium adjustments could bias our DiD estimates. To address this, we re-estimate our baseline model for bunchers in Equation (2) using the PBGC premiums as the dependent variable. As shown in column (2) of Table 9, we find no significant differences in premium changes between groups. The DiD coefficient is statistically and economically negligible. These results reinforce the internal validity of our main estimates and suggest that differential changes in PBGC premiums are not driving our findings.

**Insurance Purchases and PRT** A plausible alternative explanation for our main findings is that plans reduced equity exposures to prepare for insurance purchases or pension risk transfers (PRTs). To assess this channel, we re-estimate Equation (2) using a dummy variable indicating whether the pension plan purchased insurance (either funding or benefits insurance) as a dependent variable. As observed in column (3) of Table 9, we find no systematic differences between treatment and control plans. The DiD coefficient is both statistically and economically indistinguishable from zero. This evidence is inconsistent with the idea that the reduction in equity holdings reflects a

[33]MAP-21 increased the flat-rate premium per participant and introduced a cap on the variable rate. In 2011 the flat-rate was $35 per participant and the variable-rate was $9 per $1,000 UVBs. MAP-21 increased the flat rate per participant to $42 for 2013 and $49 for 2014, indexed to inflation thereafter. It also introduced a cap on the variable rate per participant to $400 from 2013, indexed again to inflation thereafter. Despite these adjustments, insurance payments did not increase because a decline in the ratio of pension plan assets to UVBs led to a small decline in PBGC premiums. In 2012 the median premium fell to 0.1% of total assets and 1.96% of total contributions, down from 0.15% and 2.33% in 2011, respectively, and remained at similar levels over the next three years.

higher propensity to buy insurance once MAP-21 improves funding ratios.[34] Similarly, we find no systematic differences in the likelihood of full PRTs, proxied by the absence of Schedule SB filings in later years.[35] Overall, this evidence does not support the hypothesis the post-MAP-21 de-risking was driven by intension to purchase insurance or PRTs.

**Strategic Behavior to Avoid Full Funding** Another plausible alternative explanation is that firms may wish to avoid becoming fully funded. Prior literature highlights that pension reversion taxes (Ippolito, 2001) or pressure to enhance employee benefits once surpluses emerge (Bulow and Scholes, 1983; Bodie, 1995) can induce sponsors to tilt portfolios toward safer assets as they approach full funding. However, this explanation is difficult to reconcile with the non-linearity in the response documented earlier. Under such motives, de-risking should intensify—not weaken—near full funding. The stronger de-risking for these plans runs counter to this alternative interpretation.

**Market Effects** Finally, we explore whether MAP-21-induced re-balancing differed for large plans. While our baseline estimates suggest limited aggregate market effects from MAP-21, we conduct an additional test to examine whether large plans, whose trades could "move markets", exhibit a different re-balancing behavior. Prior research shows that long-term investors, such as pensions and insurance companies, affect asset prices (Jansen, 2024; Klinger and Sundaresan, 2019; Greendwood and Vissing-Jorgensen, 2018; Greenwood and Vayanos, 2010) due to limits in arbitrage (Vayanos and Vila, 2015) and inelastic demand (Koijen and Yoko, 2019).[36]

To test this, we estimate a dynamic DiD specification with interactions for very large plans (top 10% by asset size). Since equity share is measured as a ratio of equity investments to total pension assets, market value effects may exaggerate re-balancing for larger plans. Consistent with this,

[34] Results are similar when funding and benefit insurance are considered separately (Internet Appendix Table IA6 and Internet Appendix Figure IA3). Results are also robust to extending the event window to 2017.

[35] Plans that complete a full risk transfer no longer file Schedule SB. We estimate DiD specifications for PRT incidence using event windows through 2015 or 2017. In both cases, the estimated coefficients are close to zero and statistically insignificant. Although PRT activity increased in subsequent years, it remained rare during our sample period, affecting fewer than 5% of plans (Klingler et al., 2025).

[36] Blake, Rossi, Timmermann, Tonks, and Wermers (2013) and Pástor, Stambaugh, and Taylor (2015) find that large plans often under perform smaller plans due to moving-market trades.

we find a somewhat more pronounced drop in equity shares among very large plans, though the difference is not statistically significant (Appendix Figure A2).

## 6 Conclusion

Our study investigates how funding pressure affects asset allocations and risk management strategies of US corporate DB plans, focusing on the period following the GFC when many plans struggled with substantial funding deficits. We exploit a major regulatory shock—MAP-21—which artificially eased funding pressure by boosting regulatory funding ratios and reducing their sensitivity to interest rate fluctuations. This setting allows us to identify the causal impact of reduced regulatory funding pressure on pension plans' investment choices and risk management behavior.

Our findings yield three key results. First, plans experiencing larger increases in their funding ratios from MAP-21 significantly reduced their investments in equity relative to those with smaller increases. Our dynamic DiD analysis confirms that this change occurred in 2012, when MAP-21 took effect, and reveals no differences in pre-trends between the treatment and control groups, supporting the internal validity of our empirical design. Second, similar analysis for other asset classes indicates a shift toward investment-grade bonds–the safer asset class– indicating a higher preference for safer investments once funding pressure is alleviated. Third, the cross-sectional heterogeneity in the de-risking response aligns with theoretical predictions that incentives to invest in riskier assets stem from risk-shifting motives and from attempts to limit mandatory contributions associated with regulatory funding deficits. We find no significant heterogeneity with respect to sponsor firms' Tobin's Q or dividend payout ratios, suggesting that the pre-MAP-21 risk-taking behavior was not driven by sponsor growth opportunities or payout policies.

In additional robustness tests, we further rule out several alternative explanations. We find no evidence that the observed de-risking reflects attempts to "lock-in" artificially higher funding ratios to facilitate insurance purchases. Similarly, we find no support for strategic efforts to avoid full funding, such as minimizing reversion taxes or limiting benefit increases.

We also examine whether the reduction in funding pressure affected firms' decisions to freeze their DB plans. In contrast to the asset allocation results, we find no significant reduction in the likelihood of pension freezes after MAP-21, reinforcing the idea that funding relief primarily influenced investment behavior rather than broader pension policy decisions.

From an economic perspective, the present value of pension liabilities should be calculated using the forward-looking, market-based yield curve that matches the maturity structure of promised benefits. Under this benchmark, discount rates should reflect true marginal pricing in fixed-income markets, and funding decisions would adjust continuously as market interest rates evolve. In practice, however, corporate DB pension plans operate under a heavily regulated environment in which minimum funding requirements are determined not by forward-looking market rates but by statutory formulas that rely on trailing averages of corporate bond yields. Regulatory smoothing provisions such as those introduced under MAP-21 have thus the potential to materially alter behavior even though they do not change the underlying economic value of pension liabilities. By allowing DB plans to apply higher discount rates, MAP-21 temporarily lowered the regulatory value of pension liabilities, thereby reducing required pension contributions and incentives to invest in riskier asset classes. Our results can thus be interpreted as the responses of firms to changes in regulatory values, rather than as changes in the economic value of pension liabilities.

Our paper contributes to the literature on US corporate DB plans by offering novel insights into how funding pressure influences their risk-taking and risk-management strategies and how regulatory changes, afforded to legislators, can alter these strategies. First, we show that, in the years following the GFC, many plans appeared to target large funding deficits and taking on riskier investments, especially those sponsored by financially constrained firms. Second, we document how a major regulatory change—MAP-21—shifted these strategies, reducing the incentive to hold risky assets by boosting funding ratios and lowering their sensitivity to interest rate fluctuations.

Overall, our results underscore the powerful role that regulation can play in shaping real economic behavior – even without altering the underlying economic value of pension liabilities.

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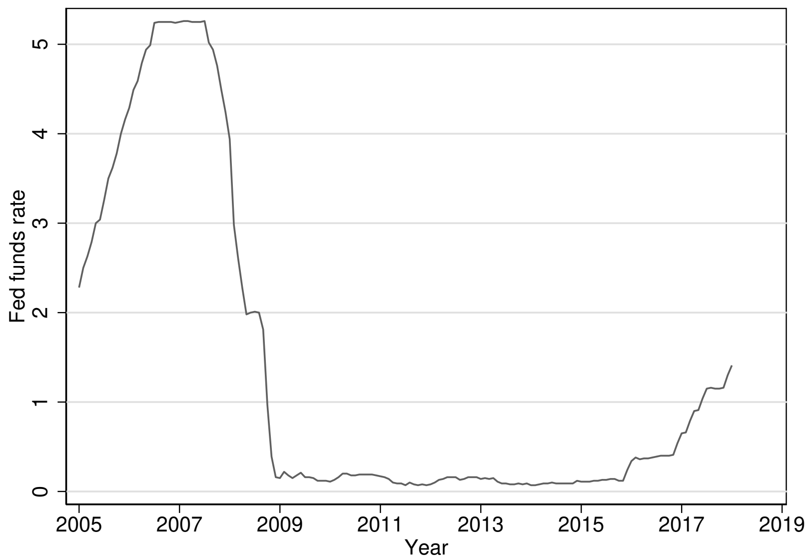
Panel A. US federal funds rate




Panel B. Median FTAP ratio


**Figure 1. Changes in the US Federal Funds Rate and US Corporate DB Plans' Funding Status**

This figure illustrates the changes in the US federal funds rates and funding status of US corporate DB plans between 2005 and 2018. Panel A reports the US federal funds rates, computed using daily data from the Reserve Bank of St. Louis. Panel B reports the median Funding Target Attainment Percentage (FTAP) across all pension plans in our sample. Data is retrieved from Schedule B and Schedule SB of the IRS 5500 main form.

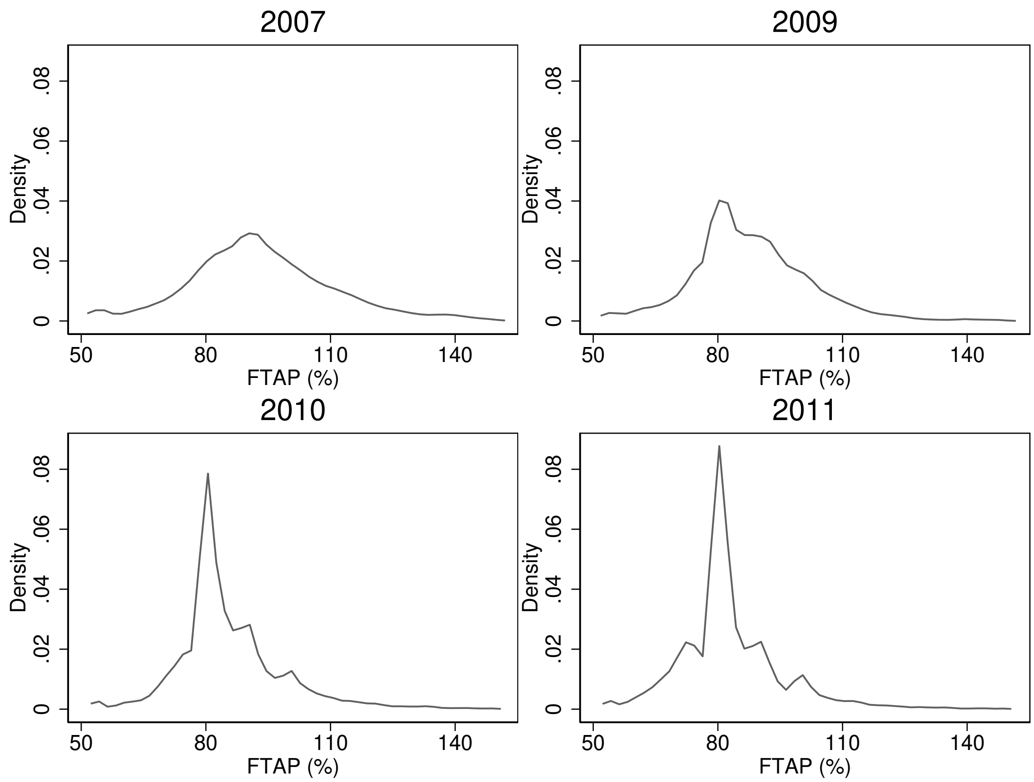



**Figure 2. Kernel Density Estimates of US Corporate DB Plans' Funding Status in Different Years**

This figure reports the kernel density estimates of US corporate DB plans' Funding Target Attainment Percentage (FTAP) in 2007, 2009, 2010, and 2011. Data is from the Form 5500 Annual Report dataset maintained by the U.S. Department of Labor. The pension FTAP information is taken from Schedule B before 2008 and Schedule SB after 2008.

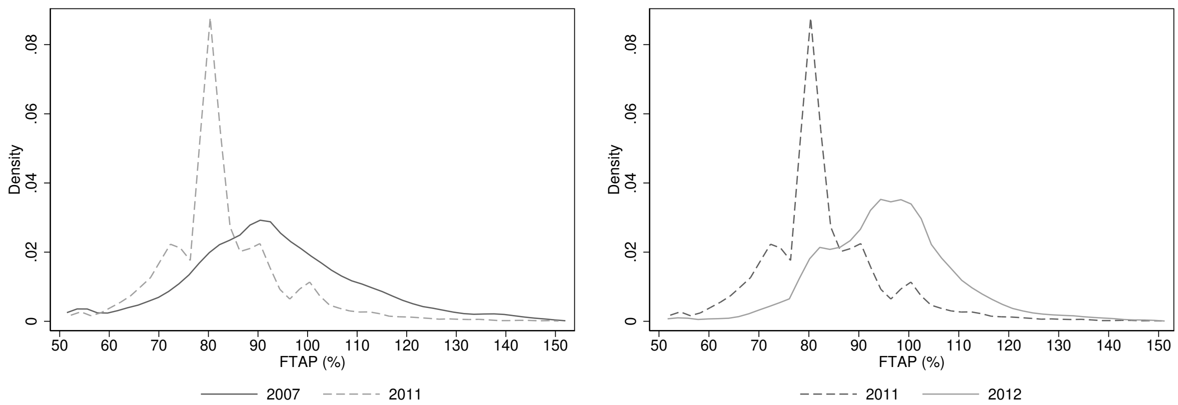



**Figure 3. Kernel Density Estimates of US Corporate DB Plans' Funding Status: Financial Crisis and MAP-21**

This figure illustrates the shifts in the kernel density estimate of pension plans' Funding Target Attainment Percentage (FTAP) after the global financial crisis (2007 vs. 2011) and after MAP-21 (2011 vs. 2012). Data is from the Form 5500 Annual Report dataset maintained by the U.S. Department of Labor. The pension FTAP information is taken from Schedule B before 2008 and Schedule SB after 2008.

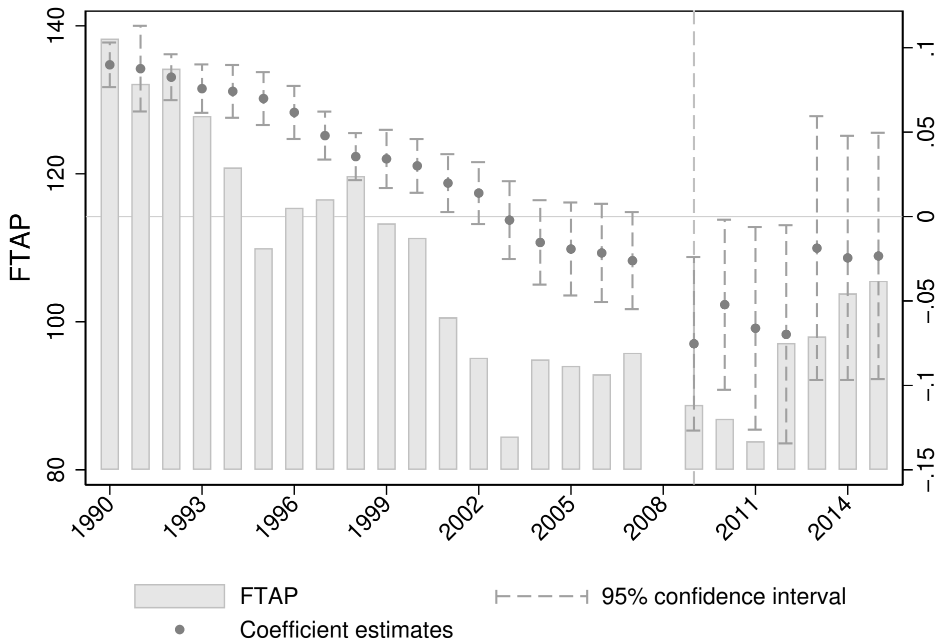
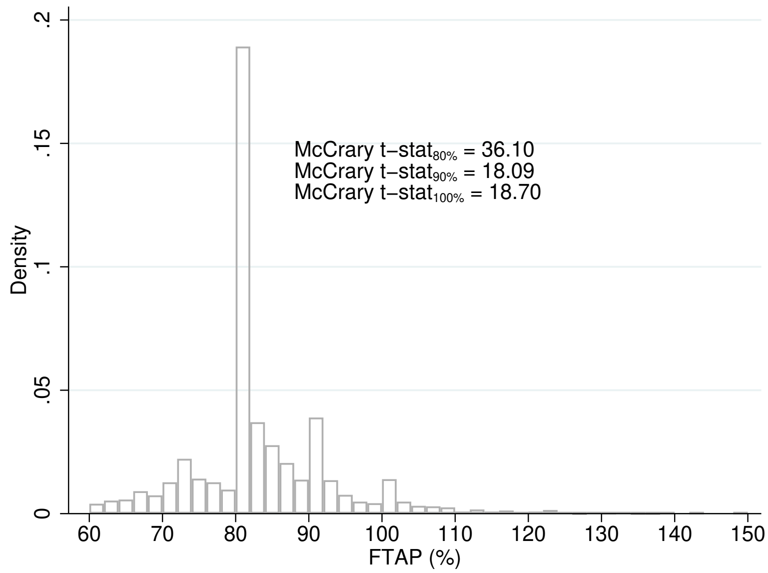



**Figure 4. Dynamic relationship between equity share and funding status**

This figure shows the relationship between pension plans' Equity Share and their funding status (FTAPs), based on the regression: $Equity\ share_{it} = \beta_0 + \beta_1 FTAP_{it} + \sum_{k \neq 1990} \beta_{2k} \left(\text{FTAP}_{it} \times \mathbb{1}_{\{t=k\}}\right) + a_i + a_t + \epsilon_{it}$. Each coefficient reflects the sum of the baseline effect ($\beta_1$) and its interaction with year ($\beta_2$), with 1990 as the baseline year ($\beta_1$). Error bars indicate the 95% confidence interval. Vertical bars indicate the average FTAP in each year for the sample of DB plans. The sample spans 1990–2015, consistent with Table 3. The dashed vertical line at 2009 marks the start of the post-crisis period when the Fed funds rate fell sharply. FTAP data come from Schedule B (pre-2009) and Schedule SB (2009 onward); asset allocation data are from Schedule H (pre-2009) and Schedule R (2009 onward). Data for 2008 are unavailable. All sources are from the Form 5500 Annual Report dataset (U.S. Department of Labor).

Panel A. Distribution of pension plans' FTAP in 2011




Panel B. Voluntary pension contributions in 2011

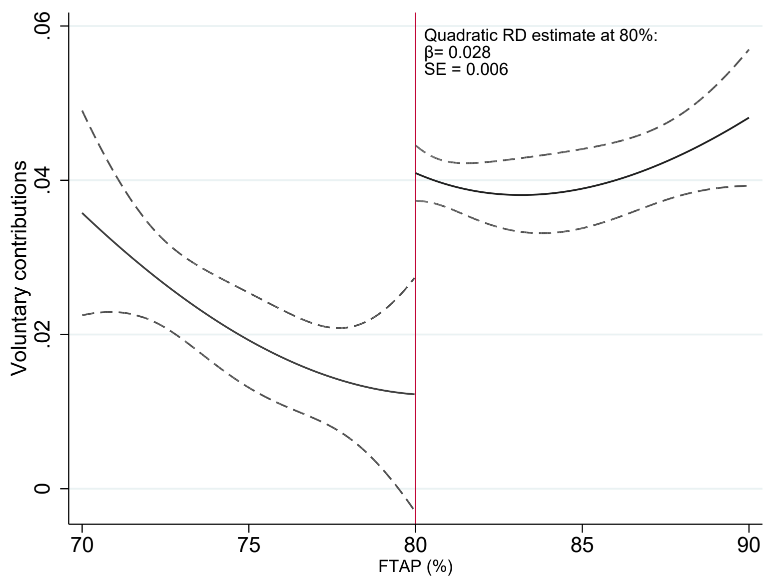



**Figure 5. Distribution of FTAP and Voluntary Pension Contributions in 2011**

Panel A reports the distribution of the Funding Target Attainment Percentage (FTAP) in 2011. The distribution is trimmed at 60% and 150%. The results of the McCrary (2008) density test for distribution discontinuities at 80%, 90% and 100% are reported in the figure. Data on pension plans' FTAP is taken from Schedule SB of the Form 5500 Annual Report dataset. Panel B displays the discontinuity in voluntary contributions in 2011 at the 80% threshold using the following polynomial regression, $\text{VolCont}_i = \beta \text{Above}_i + \sum_{s=1}^{2} \left[\gamma_s \left(\text{FTAP}_i - 80\right)^s + \delta_s \left(\text{FTAP}_i - 80\right)^s\right] \cdot \text{Above}_i + \varepsilon_i$, where $\text{VolCont}_i$ is equal to the ratio of a plan's voluntary contributions to total pension assets in 2011 and $Above_i$ equals 1 for plans with FTAPs in 2011 greater or equal to 80%, and zero otherwise. The solid line shows the mean predicted voluntary contributions from the polynomial regression, and the dotted lines show the 95% confidence interval of the predicted values. Standard errors are corrected for heteroskedasticity and clustered at the pension plan level. The vertical line indicates the 80% threshold. On the top right-hand corner of the figure to the right of the vertical line we also report the $\beta$ and its standard error.

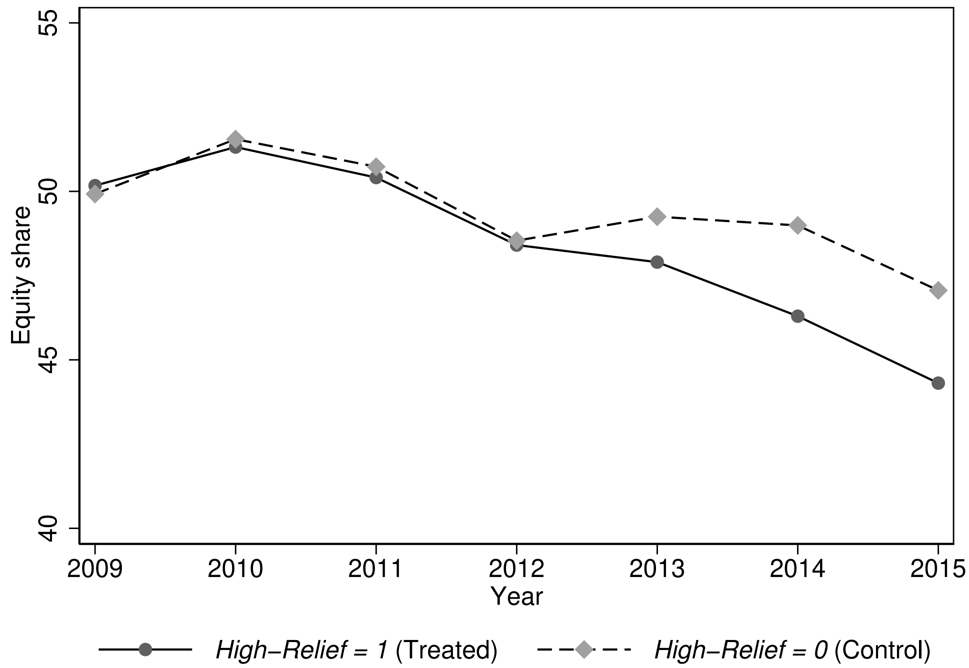



**Figure 6. Average Equity Share: Treated vs. Control Group**

This figure reports the average Equity share (i.e., fraction of assets invested in equity markets in percent) for the treatment and control groups in our main analyses. The sample consists of pension funds with 2011-FTAPs in the interval [80%, 85%], which we refer to as *'bunchers'*. The treatment (control) group includes pension plans that experienced an above (below) median increase in FTAPs from the introduction of MAP-21. The change in funding status of a DB plan is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, Equation (1), which keeps the value of assets fixed at 2011 and only captures the liability-induced change in funding status. Data on pension plans' FTAP ratios are sourced from Schedule SB and asset allocations are obtained from Schedule R, both schedules are from the Form 5500 Annual Report dataset maintained by the U.S. Department of Labor.

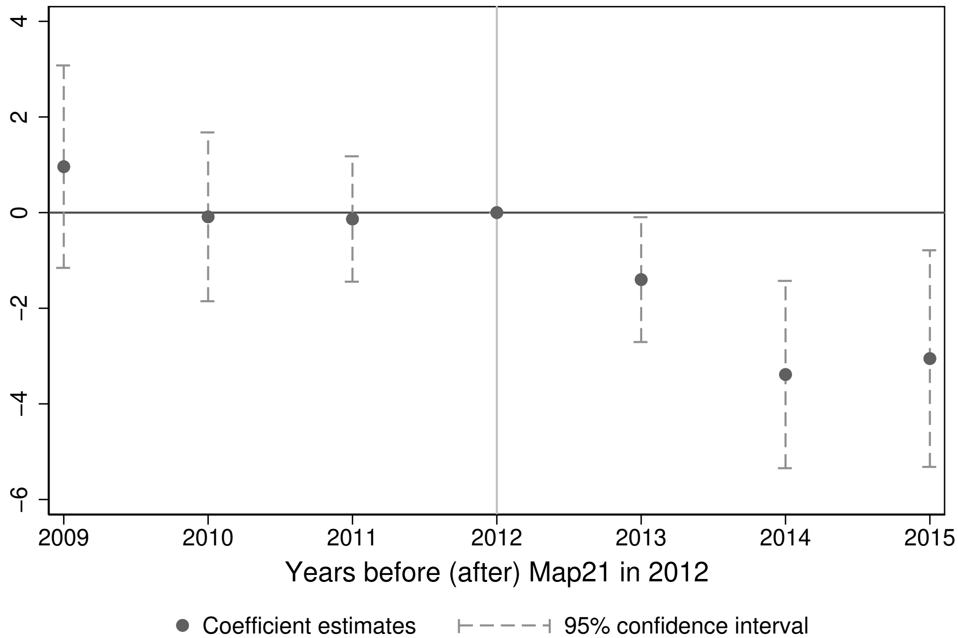



**Figure 7. Average Equity Share: Dynamic DiD for Bunchers**

The figure reports estimated DiD coefficients (and their 95% confidence intervals) of a dynamic specification of Equation (2), where the dummy variable $Post_t$ is replaced with separate dummy variables for each year from three years before to three years after MAP-21. The dependent variable is Equity share (i.e., the share of assets invested in equity). Every point estimate, represented by a dot, measures the difference in Equity share between the treatment and control group in a year relative to 2012. The sample consists only of pension funds with 2011-FTAPs in the interval [80%, 85%], which we refer to as *'bunchers'*. The treatment (control) group includes DB plans experiencing above (below) median increases in funding status from MAP-21, where the increase in funding status of a DB plan is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, Equation (1), which keeps the value of assets fixed at 2011 and only captures the liability-induced change in funding status. Standard errors are corrected for heteroskedasticity and clustered at the pension plan level. Variable definitions are available in Appendix Table A1.

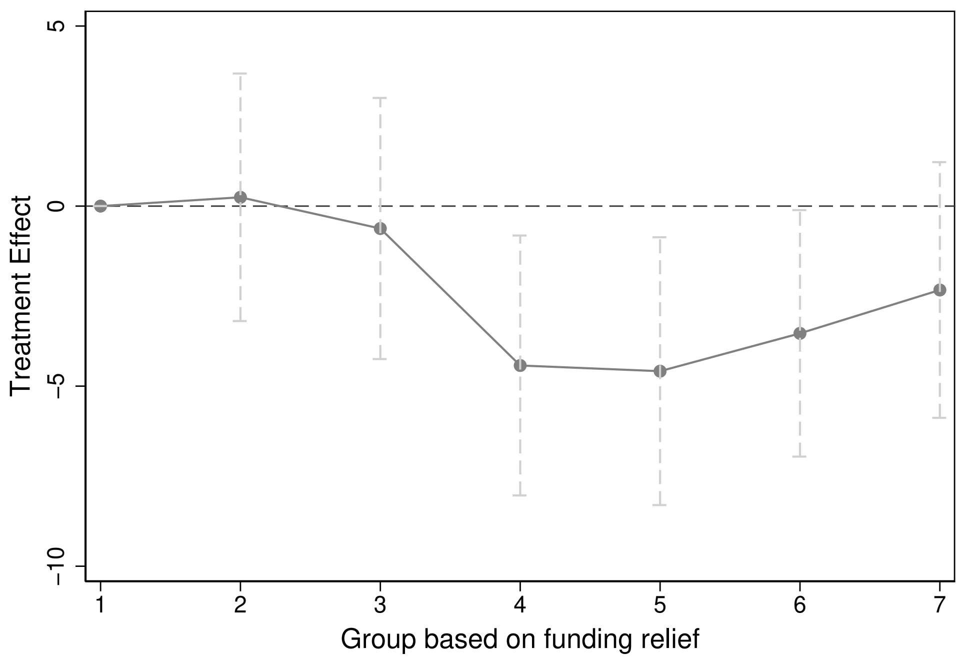



**Figure 8. Relationship to theories**

This figure plots the coefficients estimated from Equation (4). We partition the plans with *High-Relief = 1* into seven equal-sized groups based on the magnitude of funding relief implied by MAP-21. Group 1, which experiences the smallest funding relief, serves as the omitted benchmark category. Each dot represents the incremental effect on equity share for a given relief group relative to Group 1. The sample is restricted to pension funds with 2011 FTAPs in the interval [80%, 85%], which we refer to as *"bunchers"*. Standard errors are heteroskedasticity-robust and clustered at the pension plan level. Variable definitions are provided in Appendix Table A1.

**Table 1. Pension Funding Status and Federal Funds Rate Between 1990 to 2018**

This table shows the relation between pension plans' regulatory funding ratio and the US federal funds rate between 1990 and 2018. The dependent variable in column (1) is the Funding Target Attainment Percentage (FTAP) as reported in Schedule B (before 2009) and Schedule SB (from 2009 onwards) of the the Form 5500 Annual Report dataset maintained by the U.S. Department of Labor. The independent variable is the US federal funds rate, obtained from the Federal Reserve Bank of St. Louis (FRED). Columns (2) and (3) report corresponding specifications for the numerator (pension assets) and the denominator (pension liabilities) of the FTAP ratio, respectively. Pension plan fixed effects are included in all specifications. Standard errors, reported in parentheses, are corrected for heteroscedasticity and clustered at the year level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) |
|---|---|---|---|
| | FTAP ratio | Pensions assets (MM) | Pensions liabilities (MM) |
| Fed funds rate | 3.932*** | -11.189*** | -21.732*** |
| | (0.873) | (3.167) | (3.863) |
| Plan FE | Yes | Yes | Yes |
| Adj. R2 | 0.5899 | 0.4188 | 0.5927 |
| Obs. | 296,062 | 296,062 | 296,062 |
| Num. years | 28 | 28 | 28 |

**Table 2. Summary Statistics of US Corporate DB Pension Plans**

This table reports summary statistics of relevant pension characteristics, available from Schedules H, SB, and R of the the Form 5500 Annual Report dataset maintained by the U.S. Department of Labor. The sample period is from 2009 due to the availability of Schedule R and ends in 2018. We require plans to have at least 5 years of data within the sample period. MM (percentage sign; 0/1) in parentheses stands for units in million US dollars (units in percentage points; indicator variable). All variables are winsorized at the 1st and 99th percentiles. Variable definitions are available in Appendix Table A1.

| | Mean | Std. Dev. | $25^{th}$ perc. | Median | $75^{th}$ perc. | Obs. |
|---|---|---|---|---|---|---|
| Pension assets (MM) | 670.31 | 1,638.59 | 71.58 | 161.35 | 457.39 | 23,512 |
| FTAP (%) | 97.29 | 15.39 | 86.60 | 96.41 | 104.25 | 23,782 |
| Investment return | 0.08 | 0.07 | 0.03 | 0.09 | 0.13 | 22,842 |
| Contributions/Pension assets (%) | 8.04 | 311.01 | 0.20 | 4.21 | 8.21 | 22,481 |
| Premiums/Contributions (%) | 16.57 | 87.39 | 1.18 | 2.58 | 5.98 | 17,735 |
| Premiums/Pension assets (%) | 0.19 | 0.24 | 0.07 | 0.12 | 0.23 | 23,326 |
| Premiums (MM) | 0.60 | 1.21 | 0.10 | 0.20 | 0.49 | 23,668 |
| Total Participants | 8,992 | 17,557 | 1,604 | 3,039 | 7,498 | 23,668 |
| Active employee share | 0.37 | 0.23 | 0.20 | 0.35 | 0.53 | 23,618 |
| Frozen | 0.28 | 0.45 | 0.00 | 0.00 | 1.00 | 23,668 |
| Equity share (%) | 47.05 | 19.49 | 35.00 | 50.50 | 61.00 | 23,807 |
| IG bond share (%) | 34.87 | 18.73 | 23.00 | 33.00 | 44.00 | 23,807 |
| HY bond share (%) | 3.53 | 5.95 | 0.00 | 2.00 | 5.00 | 19,175 |
| Real estate share %) | 2.28 | 3.43 | 0.00 | 0.00 | 4.00 | 18,106 |
| Other share (%) | 13.07 | 17.67 | 1.50 | 6.10 | 17.90 | 21,640 |

**Table 3. Equity Share and Funding Status of US Corporate DB Plans**

The table shows the relation between a pension plan's share of assets invested in equities and the plan's Funding Target Attainment Percentage (FTAP). The model specifications are based on Rauh (2009). Columns (1) to (3) report estimation results for the sample period between 1990 and 2007. Columns (4) to (6) report corresponding results for the period between 2009 to 2015, our event window. Pension plan-fixed effects and year-fixed effects are included in all specifications. Pension assets are in billion USDs. Robust standard errors are clustered at the pension plan level and reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Dep. var.: Equity share | | | | | |
| | Sample period: [1990-2007] | | | Sample period: [2009-2015] | | |
| FTAP | 0.050*** | 0.053*** | 0.035*** | -0.057*** | -0.066*** | -0.061*** |
| | (0.005) | (0.005) | (0.006) | (0.016) | (0.016) | (0.020) |
| Active employee share | | 2.265*** | 2.171*** | | 2.422 | 1.991 |
| | | (0.732) | (0.791) | | (1.816) | (2.163) |
| Pension assets (bn) | | -8.170*** | -7.941*** | | -1.133 | -0.214 |
| | | (1.038) | (1.137) | | (1.462) | (1.688) |
| Log(Pension assets) | | -0.904** | -1.762*** | | 2.223** | 0.441 |
| | | (0.457) | (0.517) | | (1.025) | (1.205) |
| Lag (Investment return) | | | 18.812*** | | | 10.659*** |
| | | | (0.905) | | | (2.052) |
| Plan FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Adj. $R^2$ | 0.665 | 0.666 | 0.679 | 0.756 | 0.757 | 0.794 |
| Obs. | 93,102 | 92,153 | 79,605 | 19,419 | 19,388 | 15,551 |
| Num. plans | 11,849 | 11,709 | 10,600 | 3,815 | 3,809 | 3,458 |

**Table 4. Changes in the Effective Discount Rates and FTAPs: Treated vs. Control Group**

This table reports the average effective discount rates and Funding Target Attainment Percentage (FTAP) in 2011 and 2012 of the 'bunchers' (i.e., plans with 2011-FTAPs in the [80%,85%] range). The indicator variable, High-Relief, equals one if a plan experienced an above-median increase in its FTAP from MAP-21, and zero otherwise. Columns (3) reports the differences in the average values of the two groups and indicates whether they are statistically different from zero. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) |
|---|---|---|---|
| | 2011 | 2012 | Diff. |
| ***A. Effective discount rate*** | | | |
| High-Relief = 1 (Treated) | 6.037 | 7.013 | 0.976*** |
| High-Relief = 0 (Control) | 6.212 | 6.766 | 0.553*** |
| Diff. | -0.175*** | 0.248*** | 0.423*** |
| ***B. FTAP*** | | | |
| High-Relief = 1 (Treated) | 81.003 | 98.906 | 17.903*** |
| High-Relief = 0 (Control) | 81.028 | 94.274 | 13.246*** |
| Diff. | -0.025 | 4.632*** | 4.657*** |

**Table 5. Pension Plans and Sponsor Characteristics: Treated vs. Control Group**

This table compares the plan and sponsor characteristics of pension plans that experienced an above-median increase in their FTAPs from MAP-21 (High-Relief = 1) with those that saw a below-median increase (High-Relief = 0). All plan and sponsor firm characteristics are as of 2011 (i.e., the year prior to MAP-21) and are winsorized at the 1st and 99th percentiles. Columns (3) reports the differences in the average values of the two groups and indicates whether they are statistically different from zero. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | | (2) | | (3) |
|---|---|---|---|---|---|
| | High-Relief = 1 (Treated) | | High-Relief = 0 (Control) | | Diff. |
| | Mean | Std. Dev. | Mean | Std. Dev. | (1) - (2) |
| **A: Pension plans characteristics** | | | | | |
| FTAP ratio (%) | 80.99 | 1.43 | 80.98 | 1.44 | 0.00 |
| Equity share (%) | 49.87 | 18.24 | 51.29 | 16.93 | -1.42 |
| Log(Pension assets) | 19.03 | 1.38 | 19.01 | 1.38 | 0.02 |
| Total participants (K) | 11.26 | 33.33 | 9.74 | 23.08 | 1.53 |
| Frozen | 0.32 | 0.47 | 0.13 | 0.34 | 0.18*** |
| Active employee share | 0.34 | 0.18 | 0.46 | 0.21 | -0.12*** |
| **B: Sponsor firms characteristics** | | | | | |
| Log(Assets) | 8.24 | 1.35 | 8.63 | 1.35 | -0.39** |
| Book leverage | 0.26 | 0.17 | 0.27 | 0.15 | -0.00 |
| Book leverage (Tot.) | 0.35 | 0.17 | 0.34 | 0.16 | 0.02 |
| Tobin's Q | 1.51 | 0.58 | 1.56 | 0.75 | -0.06 |
| ROA | 0.16 | 0.10 | 0.15 | 0.08 | 0.01 |
| Cash-flow | 0.09 | 0.08 | 0.09 | 0.07 | -0.00 |
| Cash | 0.10 | 0.09 | 0.10 | 0.07 | 0.00 |
| R&D | 0.02 | 0.03 | 0.02 | 0.02 | 0.00 |
| Capex | 0.05 | 0.05 | 0.04 | 0.04 | 0.01 |
| Dividend | 0.01 | 0.02 | 0.02 | 0.03 | -0.00* |
| Z-score | 2.95 | 1.60 | 3.00 | 1.50 | -0.05 |

**Table 6. Changes in the Asset Allocations of Bunchers after MAP-21**

This table reports estimation results of Equation (2). The sample includes only plans with 2011-FTAPs in [80%, 85%], which we refer to as the *bunchers*. The dependent variable for each specification is the share of assets invested in each asset class: equity (column 1), investment-grade (IG) bonds (column 2), high-yield (HY) bonds (column 3), real estate (column 4), and others (column 5). The dummy variable High-Relief equals one if a plan experienced an above-median increase in its FTAP from MAP-21, and zero otherwise. The increase in a plan's FTAP is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, which keeps the value of assets fixed at 2011 and only captures the liability-induced changes in FTAP. The dummy variable Post equals one after 2012 (i.e., the year MAP-21 was enacted), and zero otherwise. The event window for estimation is three years before and three years after MAP-21, where the event year (2012) is excluded. All specifications include pension plan and industry-year fixed effects, based on sponsor firms' 3-digit NAICS code. Standard errors, corrected for heteroskedasticity and clustered at the pension plan level, are reported in parentheses below the estimated coefficients. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Equity share | IG-Bonds | HY-Bonds | Real Estate | Others |
| High-Relief × Post | -2.813*** | 2.614*** | -0.010 | -0.412* | 0.634 |
| | (0.953) | (0.926) | (0.339) | (0.220) | (0.896) |
| Plan FE | Yes | Yes | Yes | Yes | Yes |
| Industry-by-Year FE | Yes | Yes | Yes | Yes | Yes |
| Adj. $R^2$ | 0.645 | 0.632 | 0.433 | 0.563 | 0.647 |
| Obs. | 5,826 | 5,826 | 4,556 | 4,180 | 5,263 |
| Num. plans | 1,040 | 1,040 | 926 | 881 | 1,000 |

**Table 7. Cross-Sectional Heterogeneity**

This table reports estimation results of Equation (3), which allows for interactions with pension plan or sponsor characteristics, $Z$. The sample only includes plans with 2011-FTAPs in [80%, 85%], i.e., the *bunchers*. The dependent variable for each specification is Equity share (i.e., the share of assets invested in equity). The dummy variable High-Relief equals one if a plan experienced an above-median increase in its FTAP from MAP-21, and zero otherwise. The increase in a plan's FTAP is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, Equation (1), which keeps the value of assets fixed at 2011 and only captures the liability-induced changes in FTAP. The dummy variable Post equals one after 2012 (i.e., the year MAP-21 was enacted), and zero otherwise. The event window for estimation is three years before and three years after MAP-21, where the event year (2012) is excluded. Interaction variables, $Z_{i,2011}$, are defined as dummy variables based on the median value of the respective sponsor characteristic in 2011. Probability of default is measured by the Altman Z-score. Frozen is an indicator variable equal to one if a pension plan is frozen and zero otherwise. The heading of each column indicates the specific variable used in each specification. All specifications include pension plan and industry-year fixed effects, based on sponsor firms' 3-digit NAICS code. Standard errors, corrected for heteroskedasticity and clustered at the pension plan level, are reported in parentheses below the estimated coefficients. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Dep. Var.: Equity share | | | | |
| $Z_{i,2011}$: | Leverage | Prob. Default | Frozen | Tobin's Q | Dividend |
| High-Relief × Post × $Z_{i,2011}$ | -7.637** | -8.458** | 6.295** | -0.683 | 3.781 |
| | (3.487) | (3.489) | (2.513) | (3.357) | (3.359) |
| High-Relief × Post | 2.728 | 3.255 | -3.403*** | -0.728 | -3.553 |
| | (2.338) | (2.396) | (1.087) | (2.579) | (2.374) |
| Post × $Z_{i,2011}$ | 4.337* | 3.261 | -7.498*** | -1.155 | -4.523* |
| | (2.545) | (2.409) | (2.003) | (2.332) | (2.384) |
| Plan FE | Yes | Yes | Yes | Yes | Yes |
| Industry-by-year FE | Yes | Yes | Yes | Yes | Yes |
| Adj. R2 | 0.726 | 0.730 | 0.650 | 0.728 | 0.725 |
| Obs. | 2,263 | 2,127 | 5,826 | 2,177 | 2,266 |
| Num. plans | 316 | 295 | 1,040 | 303 | 317 |

**Table 8. Changes in the Pension Contributions of Bunchers after MAP-21**

This table reports estimation results of Equation (2). The sample includes only plans with 2011-FTAPs in [80%, 85%], which we refer to as the *bunchers*. The dependent variable is the natural logarithm of total (Column 1), mandatory (Column 2), and voluntary (Column 3) pension contributions. The dummy variable High-Relief equals one if a plan experienced an above-median increase in its FTAP from MAP-21, and zero otherwise. The increase in a plan's FTAP is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, which keeps the value of assets fixed at 2011 and only captures the liability-induced changes in FTAP. The dummy variable Post equals one after 2012 (i.e., the year MAP-21 was enacted), and zero otherwise. The event window for estimation is three years before and three years after MAP-21, where the event year (2012) is excluded. All specifications include pension plan and industry-year fixed effects, based on sponsor firms' 3-digit NAICS code. Standard errors, corrected for heteroskedasticity and clustered at the pension plan level, are reported in parentheses below the estimated coefficients. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) |
|---|---|---|---|
| | Log(Total) | Log(Mandatory) | Log(Voluntary) |
| High-Relief × Post | -1.167*** | -1.408*** | -0.982** |
| | (0.391) | (0.499) | (0.386) |
| Plan FE | Yes | Yes | Yes |
| Industry-by-Year FE | Yes | Yes | Yes |
| Adj. $R^2$ | 0.401 | 0.509 | 0.361 |
| Obs. | 4,116 | 4,116 | 4,116 |
| Num. plans | 979 | 979 | 979 |

**Table 9. Robustness Tests: Insurance Transfers, Plan Freezes, and PBGC Premiums**

The table presents estimates for the model specified in Equation (2) using different dependent variables. The dependent variable in column (1) is an indicator variable that equals one if a pension plan has been hard frozen, and zero otherwise. The dependent variable in column (2) is the total premium (i.e., flat plus variable components), scaled by the pension plan total value of assets, paid by the sponsor firm to insure pension benefits with the Pension Benefit Guaranty Corporation (PBGC). The dependent variable in column (3) is an indicator variable that equals one if a pension plan is covered by either funding or benefits insurance contracts, and zero otherwise. The information is retrieved from Schedule A of the Form 5500 Annual Report dataset maintained by the U.S. Department of Labor. In all cases, the sample includes only the '*bunchers*', i.e., plans with 2011-FTAPs between 80% and 85%. The dummy variable High-Relief equals one if a plan experienced an above-median increase in its FTAP from MAP-21, and zero otherwise. The increase in a plan's FTAP is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, Equation (1), which keeps the value of assets fixed at 2011 and only captures the liability-induced changes in FTAP. The dummy variable Post equals one after 2012 (i.e., the year MAP-21 was enacted), and zero otherwise. The event window for estimation spans three years before and three years after MAP-21, excluding the event year (2012). All specifications include pension plan fixed effects and industry-year fixed effects, based on sponsor firms' 3-digit NAICS code. Standard errors, corrected for heteroskedasticity and clustered at the pension plan level, are reported in parentheses below the estimated coefficients. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) |
|---|---|---|---|
| | Frozen | Premiums | Insurance |
| High-Relief × Post | 0.016 | -0.008 | -0.005 |
| | (0.018) | (0.005) | (0.011) |
| Industry-by-year FE | Yes | Yes | Yes |
| Plan FE | Yes | Yes | Yes |
| Adj. $R^2$ | 0.791 | 0.762 | 0.914 |
| Obs. | 6,075 | 6,054 | 6,075 |
| Num. plans | 1,080 | 1,077 | 1,080 |

# Appendix:

Corporate Pension Risk-Taking in a
Low Interest Rate Environment

March 24, 2026

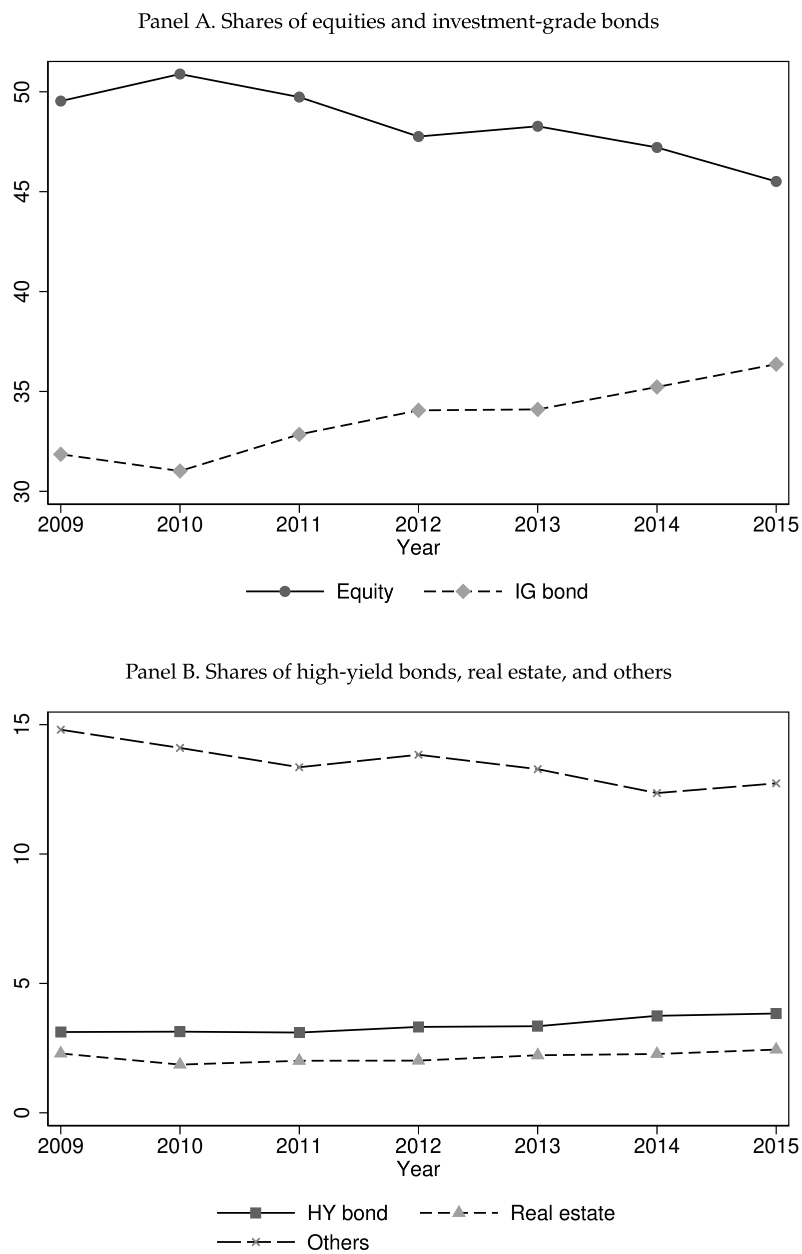



**Figure A1. Average Asset Allocation by Asset Class Over Time**

This figure reports the average asset allocation to each asset class in percentage points between 2009 and 2015. Panel A reports shares of assets invested in equities and investment-grade bonds. Panel B reports shares of all other asset classes (high-yield bonds, real estate, and others). The sample includes all available pension plans. Data is retrieved from Schedule R of the Form 5500 Annual Report dataset, available since 2009.

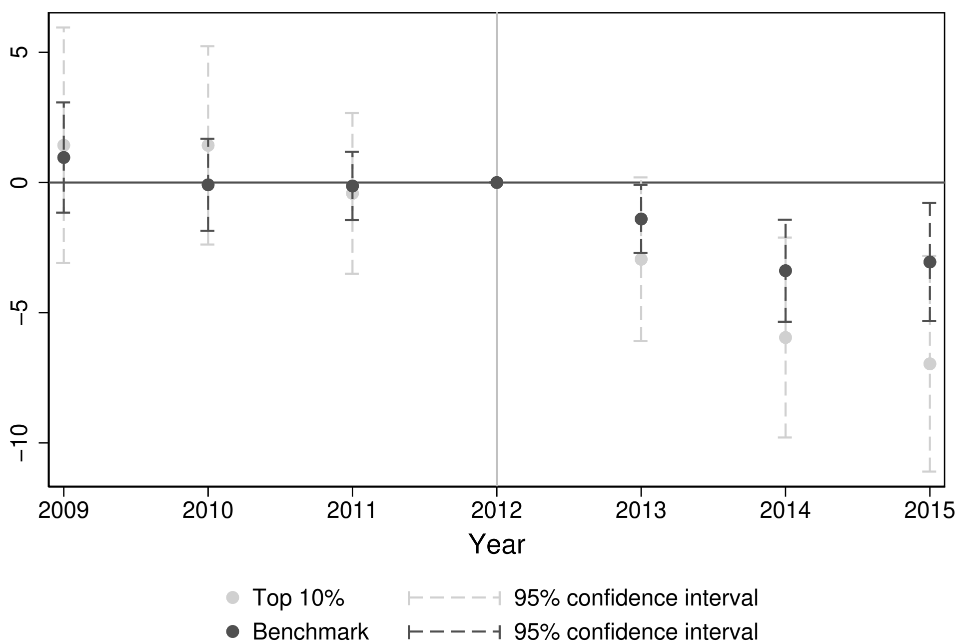



**Figure A2. Dynamic DiD Results for Equity Share: Very Large Plans**

This figure compares the estimates of the treatment coefficients for large pension plans with that for all plans in the bunchers' sample. The dark grey figure reports coefficient estimates and 95% confidence intervals of a dynamic DiD specification of our baseline model as in Figure 7. The light gray figure reports the corresponding estimates for large pension plans, obtained from an augmented dynamic DiD specification with an interaction term between High-Relief$_i$ × Post$_t$ with Large Plan$_i$, a dummy variable that equals one if a pension plan's total assets in 2011 are in the top 10% of the total asset distribution, and equals zero otherwise. The event year 2012 is the omitted group. The vertical bars around the point estimates indicate the 95% confidence interval. Standard errors are corrected for heteroskedasticity and clustered at the pension plan level.

**Table A1. List of variables and descriptions**

| Variable Label | Description |
|---|---|
| **Panel A**: Pension plan variables | |
| Pension assets | The beginning-of-year value of pension assets as reported in Schedule H of the IRS 5500 form. |
| Pension liabilities | The beginning-of-year value of pension liabilities as reported in Schedule H of the IRS 5500 form. |
| FTAP (%) | The ratio of the market value of pension assets to the projected liabilities. Line 14 in Schedule SB of the IRS 5500 form reports this variable. |
| Investment return | Following Rauh (2009), it is the income divided by beginning-of-year assets as reported in Schedule H of the IRS 5500 form. |
| Log(Total) | Natural logarithm of the total amount of contributions made towards the pension plan for the plan year by the sponsor firm (as reported in Schedule SB of the IRS 5500 form). |
| Log(Mandatory) | Natural logarithm of mandatory contributions, which are the total amount funding requirement for the plan year before reflecting carryover/prefunding balances (as reported in Schedule SB of the IRS 5500 form). |
| Log(Voluntary) | Natural logarithm of voluntary contributions, which are the difference between the total amount of pension contributions and the amount of mandatory contributions for the current plan year. |
| Active employee share | The ratio between the total number of active participants and the total number of participants at the beginning of the plan year. Both variables are in the main IRS 5500 form. |

*(Continued)*

| Variable Label | Description |
|---|---|
| Insurance | An indicator variable that equals to one if the pension plan is covered by a funding or benefits insurance contract, and zero otherwise. The information is retrieved from Schedule A of the Form 5500 Annual Report. |
| Premiums | The PBGC insurance premiums comprise of a flat and a variable component. The flat component is computed as a fixed rate times the number of participants in the pension plan. The variable rate is computed by multiplying a fixed rate per-1000 uncovered vested benefits (UVBs) of the plan up to a per-participant maximum rate. The UVBs is equal to the difference between market value of pension assets and the value of total vested benefits reported in Schedule B of the IRS-5500 form. |
| Frozen | An indicator variable equal to one if a pension plan is frozen and zero otherwise. A frozen plans is typically closed to new employees and has limited future benefit accruals for some or all active plan participants. Data is from the IRS-5500 main form. |
| Effective discount rate | The single rate of interest that is used to determine the present value of the benefits (i.e., pension liabilities) that are considered in determining the plan's funding target for a plan year. Line 5 in Schedule SB of the IRS 5500 form reports this variable. |
| Bargaining | An indicator variable that equals one when the contributions to the plan and/or the benefits paid by the plan are subject to the collective bargaining process. |
| Equity share | Percentage of plan assets held in equities as reported in Schedule R of the IRS 5500 form. |

*(Continued)*

| Variable Label | Description |
|---|---|
| IG bonds share | Percentage of plan assets held in investment grade debt as reported in Schedule R of the IRS 5500 form. |
| HY bond share | Percentage of plan assets held in high-yield debt as reported in Schedule R of the IRS 5500 form. |
| Real estate share | Percentage of plan assets held in real estate as reported in Schedule R of the IRS 5500 form. |
| Other share | Percentage of plan assets held in other securities as reported in Schedule R of the IRS 5500 form. |
| **Panel B**: Firm-level controls | |
| Log(Assets) | The logarithm of the total book value of assets. |
| Tobin's Q | Ratio between market value of assets and the total value of assets. |
| Book Leverage | Book leverage computed as the ratio between the total book value of debt and total assets. |
| Book Leverage (Tot.) | The ratio between the sum of the sponsor's book value of total debt plus pension liabilities and the sponsor's book value of firm plus pension assets (Shivdasani, Anil, and Irina Stefanescu. 2010). |
| ROA | Return on assets defined as the ratio of earnings before interest, taxes, depreciation and amortization (Compustat variable *ebitda*) and the lagged value of Total Assets (Compustat variable $at$). |
| Capex | Capital expenditure scaled by the total value of the firm's assets. |
| Cash | The vaolue of cash and short-term investments scaled by the total value of firm's assets. |
| Cash-flow | The sum of income before extraordinary items and depreciation and amortization scaled by the total value of assets. |
| R&D | Research and development expense scaled by the total value of assets. |

*(Continued)*

| Variable Label | Description |
| --- | --- |
| Dividend | The total amount of dividends scaled by the total value of assets. |
| Z-score | The Altman Z-Score index. |

**Table A2. Characteristics of Sponsor Firms: Bunchers vs. Other Groups**

This table reports summary statistics of sponsor firm characteristics of pension plans based on Funding Target Attainment Percentage (FTAP) in 2011. Column (1) reports the mean and standard deviation for sponsor characteristics of plans with a 2011-FTAP within the [80%, 85%] range. Column (2) reports the mean and standard deviation for sponsor characteristics of plans with a 2011-FTAP within the [70%, 80%) range. Finally, column (4) reports the mean and standard deviation for sponsor characteristics of plans with a 2011-FTAP within the [100%, 150%] range. All variables are as of 2011 value – the year prior to MAP-21 when these groups are determined based on their FTAP – and winsorized at the 1st and 99th percentiles. Columns (3) and (5) report differences in means between our group of interest, [80%, 85%], and the [70%, 80%) in column (3) and [100%, 150%] in column (5). ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | | (2) | | (3) | (4) | | (5) |
|---|---|---|---|---|---|---|---|---|
| | [80%-85%] | | [70%-80%) | | Diff. | [100%-150%] | | Diff. |
| | Mean | Std. Dev. | Mean | Std. Dev. | (1)-(2) | Mean | Std. Dev. | (1)-(4) |
| Log(Assets) | 8.44 | 1.36 | 7.74 | 1.59 | 0.70*** | 8.54 | 1.41 | -0.10 |
| Book leverage | 0.26 | 0.16 | 0.33 | 0.22 | -0.07** | 0.20 | 0.12 | 0.06* |
| Book leverage (Tot.) | 0.34 | 0.16 | 0.47 | 0.23 | -0.13*** | 0.27 | 0.13 | 0.07** |
| Tobin's Q | 1.53 | 0.68 | 1.36 | 0.40 | 0.17* | 1.44 | 0.51 | 0.10 |
| ROA | 0.15 | 0.09 | 0.12 | 0.05 | 0.03** | 0.13 | 0.07 | 0.02 |
| Cash-flow | 0.09 | 0.07 | 0.06 | 0.09 | 0.03** | 0.09 | 0.06 | 0.00 |
| Cash holding | 0.10 | 0.08 | 0.09 | 0.13 | 0.01 | 0.11 | 0.07 | -0.01 |
| R&D | 0.02 | 0.03 | 0.02 | 0.04 | -0.00 | 0.01 | 0.02 | 0.01 |
| Capex | 0.04 | 0.04 | 0.04 | 0.03 | 0.01 | 0.04 | 0.03 | 0.01 |
| Dividend | 0.02 | 0.02 | 0.01 | 0.02 | 0.01** | 0.02 | 0.03 | -0.01 |
| Z-score | 2.97 | 1.51 | 2.07 | 1.39 | 0.90*** | 3.48 | 1.63 | -0.51* |

**Table A3. Relief Intensity and Pension Conservativeness**

This table reports estimation results from a linear probability model (Column 1) and a logit model (Column 2), where the dependent variable is *High-Relief*, an indicator equal to one if a plan experienced an above-median increase in its FTAP due to MAP-21, and zero otherwise. The increase in a plan's FTAP is defined in Equation 1. The key independent variable is a measure of pension plan conservativeness, based on the share of assets invested in equities: a plan is classified as conservative if its equity share falls below the sample median. Panel A defines conservative plans using portfolio allocations from 2009-2010, while Panel B uses allocations from the 2000–2007 period.

| | (1) | (2) |
|---|---|---|
| | Dep. var: High Relief | |
| | Panel A: Selection 2009-2010 | |
| | OLS | Logit |
| Conservative Plans | -0.001 | -0.005 |
| | (0.031) | (0.123) |
| | Panel B: Selection 2000-2007 | |
| | OLS | Logit |
| Conservative Plans | -0.007 | -0.027 |
| | (0.035) | (0.140) |
| Obs. | 1,091 | 1,091 |

**Table A4. DiD Analysis With Propensity Score Matching**

This table presents the estimates from our baseline difference-in-differences (DiD) model using a matched sample. Specifically, we matched High-Relief (i.e., treated) and Low-Relief (i.e., control) plans based on their 2011-value of plan assets, share of active participants, and frozen status. The dependent variable for each specification is the share of assets invested in each asset class: equity (column 1), investment-grade (IG) bonds (column 2), high-yield (HY) bonds (column 3), real estate (column 4), and others (column 5). The dummy variable High-Relief equals one if a plan experienced an above-median increase in its FTAP from MAP-21, and zero otherwise. The increase in a plan's FTAP is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, Equation (1), which keeps the value of assets fixed at 2011 and only captures the liability-induced changes in FTAP. The dummy variable Post equals one after 2012 (i.e., the year MAP-21 was enacted), and zero otherwise. The event window for estimation is three years before and three years after MAP-21, where the event year (2012) is excluded. All specifications include pension plan and industry-year fixed effects, based on sponsor firms' 3-digit NAICS codes. Standard errors, corrected for heteroskedasticity and clustered at the pension plan level, are reported in parentheses below the estimated coefficients. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Equity | IG-Bonds | HY-Bonds | Real Estate | Other |
| High-Relief × Post | -2.945*** | 2.295** | 0.258 | -0.132 | 0.830 |
| | (1.134) | (1.105) | (0.406) | (0.229) | (1.136) |
| Plan FE | Yes | Yes | Yes | Yes | Yes |
| Industry-by-Year FE | Yes | Yes | Yes | Yes | Yes |
| Adj. $R^2$ | 0.656 | 0.641 | 0.398 | 0.623 | 0.637 |
| Obs. | 4,256 | 4,256 | 3,346 | 3,100 | 3,866 |
| Num. plans | 763 | 763 | 681 | 656 | 737 |

**Table A5. Robustness: DiD Analysis with Alternative Pension Relief**

This table presents the estimates from our baseline difference-in-differences (DiD) model using an alternative measure of pension relief. The dummy variable High-Relief equals one if a plan experienced an above-median increase in its FTAP from MAP-21, and zero otherwise. In Column (1), the pension funding relief is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, Equation (1), which keeps the value of assets fixed at 2011 and only captures the liability-induced changes in FTAP. In Column (3), we follow the approach of Dambra (2018) and measure pension funding relief using the change in mandatory contributions prompted by MAP-21 implementation. The dummy variable Post equals one after 2012 (i.e., the year MAP-21 was enacted), and zero otherwise. For reference, Column (1) reports our baseline estimate. Column (2) reports the estimate using the alternative pension relief measure. The event window for all estimations is three years before and three years after MAP-21, where the event year (2012) is excluded. All specifications include pension plan and industry-year fixed effects, based on sponsor firms' 3-digit NAICS codes. Standard errors, corrected for heteroskedasticity and clustered at the pension plan level, are reported in parentheses below the estimated coefficients. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) |
|---|---|---|
| | Dep. var.: Equity share | |
| | Baseline | Alt. Pension Relief |
| High-Relief x Post | -2.813*** | -1.617* |
| | (0.953) | (0.954) |
| Plan FE | Yes | Yes |
| Industry-by-Year FE | Yes | Yes |
| Adj. $R^2$ | 0.645 | 0.651 |
| Obs. | 5,826 | 5,151 |
| Num. plans | 1,040 | 919 |

**Table A6. DiD Adjusting Asset Classes for Market Performance**

This table reports estimates of Equation 2 using an adjusted measure of the share of assets invested in each asset class. For each class, we compute the value of investments net of the performance of the closest benchmark index and then recalculate the corresponding asset share. The sample includes only plans with 2011-FTAPs in [80%, 85%], which we refer to as the bunchers. For equity, we adjust values using the S&P 500; for investment-grade (IG) bonds, the Bloomberg US Aggregate Bond Index; for high-yield (HY) bonds, the ICE BofA US High Yield Index Total Return Index; for real estate, the MSCI US REIT Index; and for the "other" category, the S&P 500, implicitly assuming these assets earned at least the market return. The dependent variable in each specification is the adjusted asset-class share: equity (column 1), IG bonds (column 2), HY bonds (column 3), real estate (column 4), and other assets (column 5). The dummy variable High-Relief equals one if a plan experienced an above-median increase in its FTAP from MAP-21, and zero otherwise. The increase in a plan's FTAP is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, which keeps the value of assets fixed at 2011 and only captures the liability-induced changes in FTAP. The dummy variable Post equals one after 2012 (i.e., the year MAP-21 was enacted), and zero otherwise. The event window for estimation is three years before and three years after MAP-21, where the event year (2012) is excluded. All specifications include pension plan and industry-year fixed effects, based on sponsor firms' 3-digit NAICS code. Standard errors, corrected for heteroskedasticity and clustered at the pension plan level, are reported in parentheses below the estimated coefficients. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1)<br>Equity | (2)<br>IG-Bonds | (3)<br>HY-Bonds | (4)<br>Real Estate | (5)<br>Other |
|---|---|---|---|---|---|
| High-Relief × Post | -3.601*** | 3.384*** | 0.011 | -0.478** | 0.820 |
| | (1.234) | (1.157) | (0.378) | (0.212) | (1.144) |
| Plan FE | Yes | Yes | Yes | Yes | Yes |
| Industry-by-Year FE | Yes | Yes | Yes | Yes | Yes |
| Adj. $R^2$ | 0.632 | 0.634 | 0.450 | 0.552 | 0.614 |
| Obs. | 4,832 | 4,832 | 4,098 | 3,851 | 4,489 |
| Num. plans | 1,027 | 1,027 | 882 | 833 | 968 |

**Internet Appendix:**

# Corporate Pension Risk-Taking in a Low Interest Rate Environment

March 24, 2026

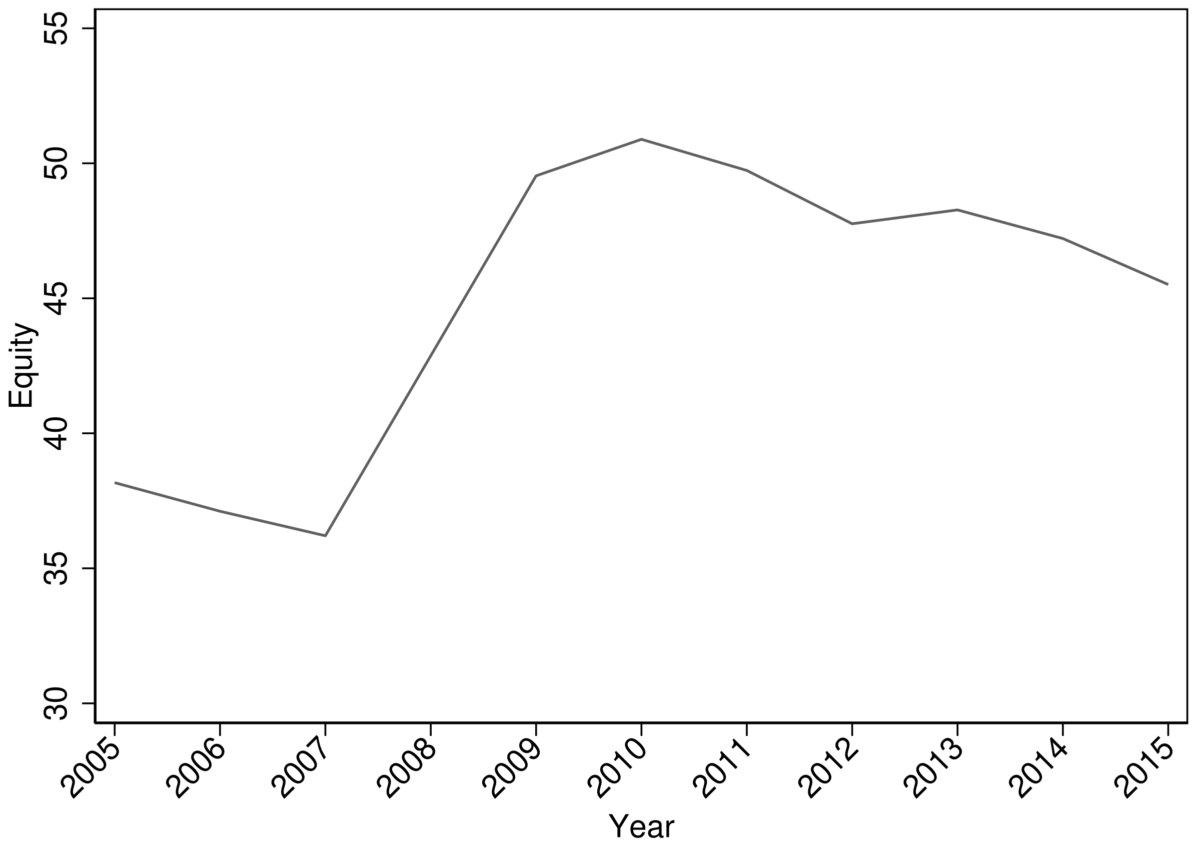



**Figure IA1. Average Share of Equity Over Time**

This figure reports the average equity share (i.e., fraction of assets invested in equity, in percentage points) of US corporate DB pensions between 2005 and 2015. Data is retrieved from Schedule H (before 2009) and Schedule R (since 2009) of the Form 5500 Annual Report dataset.

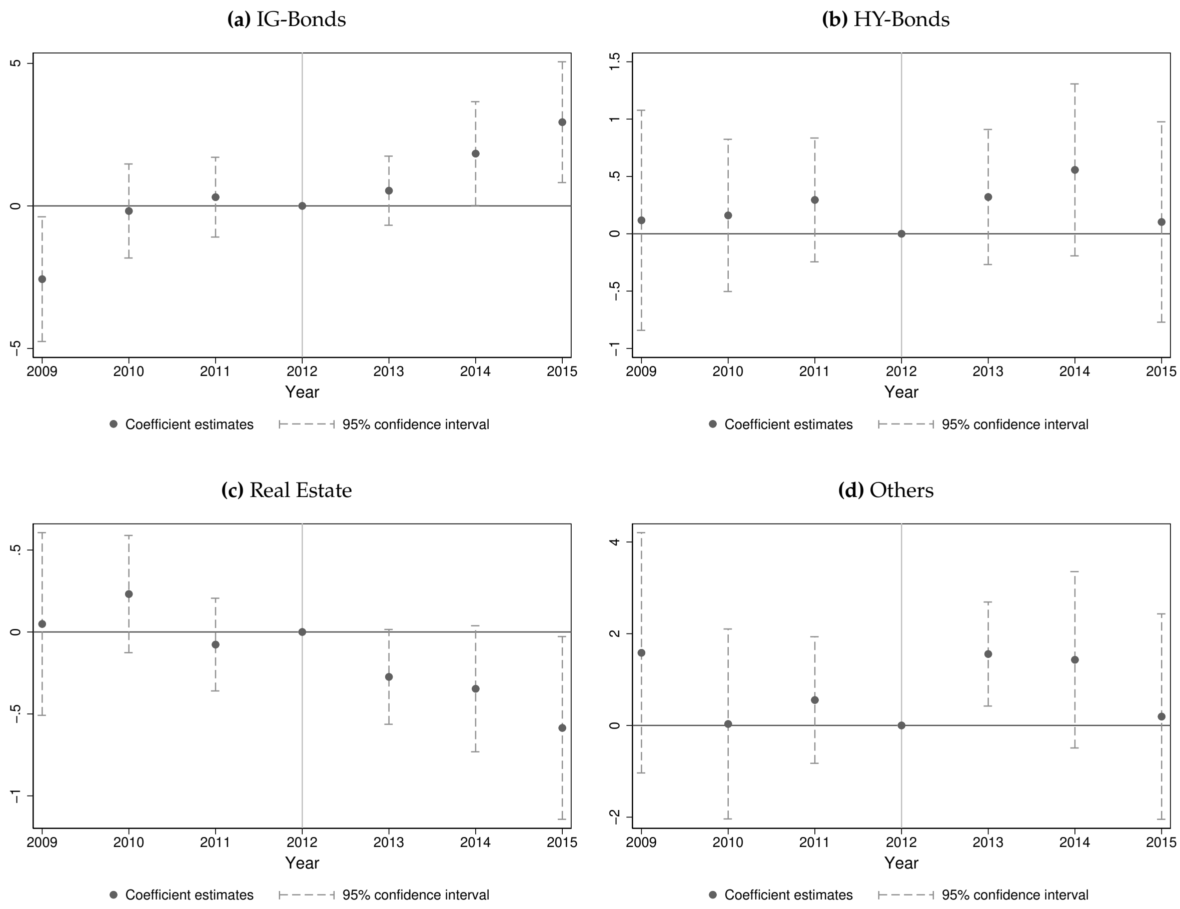



**Figure IA2. Dynamic DiD for Bunchers: Other Asset Classes**

The figure reports estimated DiD coefficients (and their 95% confidence intervals) of a dynamic specification of Equation (2) in the paper, where the dummy variable $Post_t$ is replaced with separate dummy variables for each year from three years before to three years after MAP-21. The dependent variables are IG-Bonds, HY-Bonds, Real Estate, and Others (i.e., the share of assets invested in each of these asset classes). Every point estimate, represented by a dot, measures the difference in Equity share between the treatment and control group in a year relative to 2012. The sample consists only of pension funds with 2011-FTAPs in the interval [80%, 85%], which we refer to as *'bunchers'*. The treatment (control) group includes DB plans experiencing above (below) median increases in funding status from MAP-21, where the increase in funding status of a DB plan is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, Equation (1) in the paper, that keeps the value of assets fixed at 2011 and only captures the liability-induced change in funding status. Standard errors are corrected for heteroskedasticity and clustered at the pension plan level.

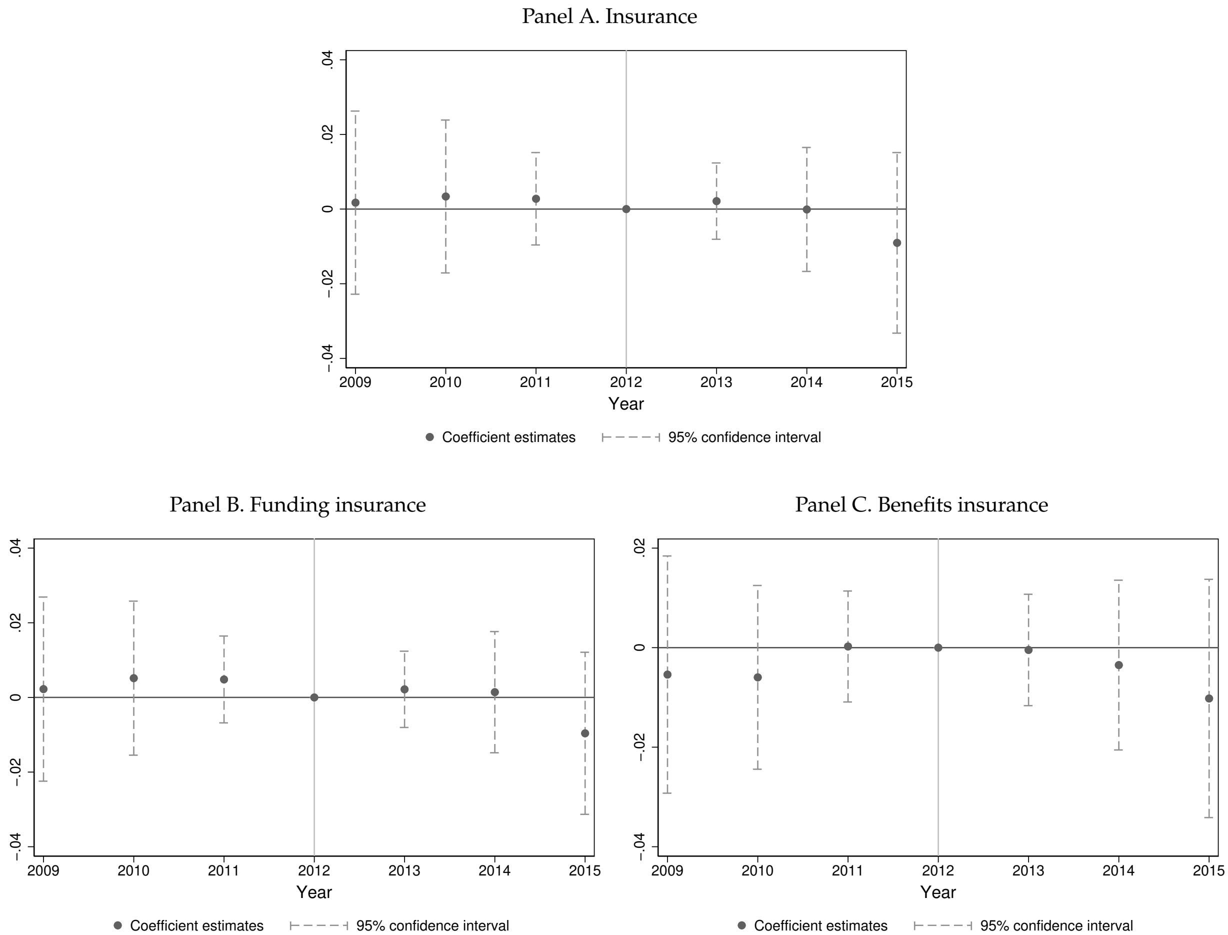



**Figure IA3. Dynamic DiD by Type of Insurance**

The figure reports estimated DiD coefficients (and their 95% confidence intervals) of a dynamic specification of Equation (2), where the dummy variable $Post_t$ is replaced with separate dummy variables for each year from three years before to three years after MAP-21. The dependent variable is an indicator variable that equals to one if the pension plan is covered by a funding or benefits insurance contracts (Panel A), only funding insurance contracts (Panel B), or only benefits insurance contracts (Panel C), and zero otherwise. The information is retrieved from Schedule A of the Form 5500 Annual Report dataset maintained by the U.S. Department of Labor. The sample consists of DB pension plans with 2011-FTAPs in [80%, 85%]. The corresponding treatment (control) group includes DB plans experiencing above (below)-median increases in funding status from MAP-21, where the increase in funding status of a DB plan is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, Equation (1), which keeps the value of assets fixed at 2011 and only captures the liability-induced change in funding status. All specifications include pension plan fixed effects and industry-year fixed effects, based on sponsor firms' 3-digit NAICS code. Standard errors are corrected for heteroskedasticity and clustered at the pension plan level. Variable definitions are available in Appendix Table A1.

**Table IA1. Robustness: Changes in the Asset Allocations of Bunchers after MAP-21**

This table reports estimation results of Equation (2) of the paper. In Panel A, the sample includes only plans with 2011-FTAPs in [80%, 85%], which we refer to as the *bunchers* and excludes plans with a common sponsor firm. In Panel B, we use our baseline sample of plans with 2011-FTAPs in [80%, 85%] and cluster standard errors at the sponsor level. The dependent variable for each specification is the share of assets invested in each asset class: equity (column 1), investment-grade (IG) bonds (column 2), high-yield (HY) bonds (column 3), real estate (column 4), and others (column 5). The dummy variable High-Relief equals one if a plan experienced an above-median increase in its FTAP from MAP-21, and zero otherwise. The increase in a plan's FTAP is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, which keeps the value of assets fixed at 2011 and only captures the liability-induced changes in FTAP. The dummy variable Post equals one after 2012 (i.e., the year MAP-21 was enacted), and zero otherwise. The event window for estimation is three years before and three years after MAP-21, where the event year (2012) is excluded. All specifications include pension plan and industry-year fixed effects, based on sponsor firms' 3-digit NAICS code. Standard errors, corrected for heteroskedasticity and clustered at the pension plan (in Panel A) and sponsor (in Panel B) level, are reported in parentheses below the estimated coefficients. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Panel A: Excluding common sponsor firms | | | | |
| | Equity share | IG-Bonds | HY-Bonds | Real Estate | Others |
| High-Relief × Post | -2.121** | 2.752*** | -0.084 | -0.467* | -0.125 |
| | (1.058) | (1.047) | (0.366) | (0.256) | (0.986) |
| Plan FE | Yes | Yes | Yes | Yes | Yes |
| Industry-by-Year FE | Yes | Yes | Yes | Yes | Yes |
| Adj. $R^2$ | 0.624 | 0.619 | 0.453 | 0.538 | 0.650 |
| Obs. | 4,871 | 4,871 | 3,717 | 3,378 | 4,389 |
| Num. plans | 871 | 871 | 765 | 722 | 834 |
| | Panel B: Clustering at sponsor level | | | | |
| | Equity share | IG-Bonds | HY-Bonds | Real Estate | Others |
| High-Relief × Post | -2.813*** | 2.614*** | -0.010 | -0.412* | 0.634 |
| | (0.984) | (0.935) | (0.336) | (0.234) | (0.944) |
| Plan FE | Yes | Yes | Yes | Yes | Yes |
| Industry-by-Year FE | Yes | Yes | Yes | Yes | Yes |
| Adj. $R^2$ | 0.645 | 0.632 | 0.434 | 0.563 | 0.647 |
| Obs. | 5,826 | 5,826 | 4,556 | 4,180 | 5,263 |
| Num. cluster | 933 | 933 | 827 | 784 | 895 |

**Table IA2. Robustness Test: Equity Share and Funding Status**

The table presents the results of estimating a panel regression model that examines the relationship between pension plans' equity share and their FTAPs. The model specifications are based on Rauh (2009). The sample period covers 1990 to 2007 and includes exclusively those pension plans that are present in our baseline sample period from 2009 to 2015. This selection ensures that the observed sign flip in the later period is not due to changes in sample composition caused by plans leaving the sample. All specifications include pension plan and year fixed effects. Pension assets are reported in billions of USD. Robust standard errors, clustered at the pension plan level, are reported in parentheses. Significance levels are indicated by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) |
|---|---|---|---|
| | Sample period: [1990-2007] | | |
| | Equity share | | |
| FTAP | 0.054*** | 0.058*** | 0.035** |
| | (0.011) | (0.012) | (0.014) |
| Active employee share | | -0.235 | -0.748 |
| | | (2.345) | (2.481) |
| Pension assets (bn) | | -5.309*** | -5.481*** |
| | | (1.804) | (1.971) |
| Log(Pension assets) | | -0.017 | -0.185 |
| | | (0.962) | (1.061) |
| Lag (Investment return) | | | 18.392*** |
| | | | (2.226) |
| Adj. $R^2$ | 0.616 | 0.617 | 0.631 |
| Obs. | 16,887 | 16,827 | 15,041 |
| Num. plans | 1,757 | 1,755 | 1,683 |

**Table IA3. Robustness Tests: Narrower FTAP Range to Define Bunchers**

This table reports robustness analysis of Equation (2) for bunchers' with above vs. below median increase in funding status using narrower windows above the 80% threshold i.e., with 2011-FTAPs in [80%, 84%], [80%, 83%], and [80%, 82%], respectively. The dependent variable in all specifications is the share of assets invested equities. The dummy variable High-Relief equals one if a plan experienced an above-median increase in its FTAP from MAP-21, and zero otherwise. The increase in a plan's FTAP is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, Equation (1), which keeps the value of assets fixed at 2011 and only captures the liability-induced changes in FTAP. The dummy variable Post equals one after 2012 (i.e., the year MAP-21 was enacted), and zero otherwise. The event window for estimation is three years before and three years after MAP-21, where the event year (2012) is excluded. All specifications include pension plan and industry-year fixed effects, based on sponsor firms' 3-digit NAICS code. Standard errors, corrected for heteroskedasticity and clustered at the pension plan level, are reported in parentheses below the estimated coefficients. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) |
|---|---|---|---|
| | Dep. Var.: Equity share | | |
| | [80%, 84%] | [80%, 83%] | [80%, 82%] |
| High-Relief × Post | -2.537** | -2.468** | -2.394** |
| | (0.995) | (1.040) | (1.088) |
| Industry-by-year FE | Yes | Yes | Yes |
| Plan FE | Yes | Yes | Yes |
| Adj. $R^2$ | 0.653 | 0.655 | 0.673 |
| Obs. | 5,409 | 4,963 | 4,458 |
| Num. plans | 967 | 888 | 795 |

**Table IA4. Pension Plans Characteristics After Matching: Treated vs. Control Group**

This table compares the characteristics of pension plans that experienced an above-median increase in their FTAPs from MAP-21 (High-Relief = 1) with those that saw a below-median increase (High-Relief = 0) after the propensity score matching. All plan and sponsor firm characteristics are as of 2011 (i.e., the year prior to MAP-21) and are winsorized at the 1st and 99th percentiles. Columns (3) reports the differences in the average values of the two groups and indicates whether they are statistically different from zero. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | | (2) | | (3) |
|---|---|---|---|---|---|
| | High-Relief = 1 (Treated) | | High-Relief = 0 (Control) | | Diff. |
| | Mean | Std. Dev. | Mean | Std. Dev. | (1) - (2) |
| FTAP ratio (%) | 81.003 | 1.434 | 80.914 | 1.309 | 0.088 |
| Equity share (%) | 50.346 | 17.298 | 51.815 | 17.653 | -1.468 |
| Log(Pension assets) | 18.914 | 1.409 | 18.925 | 1.293 | -0.012 |
| Total participants (K) | 11.913 | 35.508 | 10.740 | 24.487 | 1.173 |
| Frozen | 0.315 | 0.465 | 0.298 | 0.458 | 0.017 |
| Active employee share | 0.339 | 0.181 | 0.333 | 0.175 | 0.005 |

**Table IA5. Robustness: Cross-sectional heterogeneity**

This table reports estimation results for an augmented version of Equation (3), allowing for interactions with pension plan or sponsor characteristics, Z. The sample only includes plans with 2011-FTAPs in [80%, 85%], i.e., the *bunchers*. The dependent variable for each specification is Equity share (i.e., the share of assets invested in equity). The dummy variable High-Relief equals one for pension plans with an above-median increase in funding status from MAP-21, and zero otherwise. The increase in funding status of a DB plan is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, Equation (1), which keeps the value of assets fixed at 2011 and only captures the liability-induced change in funding status. The dummy variable Post equals one after 2012 (i.e., the year MAP-21 was enacted), and zero otherwise. The event window for estimation is three years before and three years after MAP-21, with the event year (2012) excluded. To facilitate the interpretation of the estimated coefficients and avoid simultaneity problems, all interaction variables, $Z_{i,2011}$, are defined as dummy variables based on the median value of the characteristic in 2011. The variable Bargaining is dichotomous (1/0) by design. Therefore, we set it to its 2011 value. Column (1) sorts plans based on the ratio between pension and sponsor firm asset values. Column (2) sorts plans based on the ratio between mandatory contributions towards the plan and the sponsor net income. Column (3) sorts plans based on whether contributions and/or benefits to the plan are subject to a collective bargaining process. All specifications include pension plan and industry-year fixed effects, based on sponsor firms' 3-digit NAICS code. Standard errors, corrected for heteroskedasticity and clustered at the pension plan level, are reported in parentheses below the estimated coefficients. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) | (3) |
|---|---|---|---|
| | Dependent variable: Equity share | | |
| $Z_{i,2011}$: | Plan/sponsor size | Contr./Net-income | Bargaining |
| High-Relief × Post × $Z_{i,2011}$ | 0.530 | -2.961 | 3.832 |
| | (3.348) | (3.473) | (3.692) |
| High-Relief × Post | -1.390 | 0.330 | -2.527 |
| | (2.508) | (2.441) | (2.137) |
| Post × $Z_{i,2011}$ | -4.459* | -0.279 | -4.370* |
| | (2.274) | (2.324) | (2.357) |
| Plan FE | Yes | Yes | Yes |
| Industry-by-year FE | Yes | Yes | Yes |
| Adj. $R^2$ | 0.726 | 0.725 | 0.725 |
| Obs. | 2,266 | 2,210 | 2,266 |
| Num. plans | 317 | 311 | 317 |

**Table IA6. Robustness Tests - DiD Results for Funding and Benefit Insurance Contracts**

The table presents estimates for the model specified in Equation (2), where the dependent variable is an indicator capturing the purchase of either funding or benefits insurance by the DB corporate pension plans in our sample. The information is retrieved from Schedule A of the Form 5500 Annual Report dataset maintained by the U.S. Department of Labor. We analyze pension plans we categorize as '*bunchers*', which refers to plans whose funding status in 2011 falls between 80% and 85%. This model compares the purchase of insurance by plans above versus below the median increase in funding status following the introduction of MAP-21. The dummy variable High-Relief equals one for pension plans with an above-median increase in funding status, and zero otherwise. The increase in funding status of a DB plan is measured by $Assets_{2011}/Liabilities_{2012} - Assets_{2011}/Liabilities_{2011}$, Equation (1), which keeps the value of assets fixed at 2011 and only captures the liability-induced change in funding status. The dummy variable Post equals one after 2012 (i.e., the year MAP-21 was enacted), and zero otherwise. The event window for estimation spans three years before and three years after MAP-21, excluding the event year (2012). All specifications include pension plan fixed effects and industry-by-year fixed effects, based on sponsor firms' 3-digit NAICS code. Standard errors, corrected for heteroskedasticity and clustered at the pension plan level, are reported in parentheses below the estimated coefficients. Significance levels are denoted by ***, **, and * for significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are available in Appendix Table A1.

| | (1) | (2) |
|---|---|---|
| | Funding insurance | Benefits insurance |
| High-Relief × Post | -0.006 | -0.001 |
| | (0.010) | (0.010) |
| Industry-by-year FE | Yes | Yes |
| Plan FE | Yes | Yes |
| Adj. $R^2$ | 0.918 | 0.916 |
| Obs. | 6,075 | 6,075 |
| Num. plans | 1,080 | 1,080 |