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Risk Shifting in Pension Investment

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Abstract: We re-visit if risk shifting behavior exists in the investment of defined benefit (DB) plan assets. Extending prior literature, we emphasize that both financial distress of the sponsors and severe underfunding of the pension plans need to be present before it becomes optimal for the sponsors to shift pension investment risk. Our results from the analysis of the levels as well as changes in pension asset allocations, supplemented by the DB plan terminations data from the Pension Benefit Guaranty Corporation (PBGC), are consistent with the presence of risk shifting behavior. We also find that risk shifting is mitigated in the U.K. where the pension insurance premium is risk adjusted. Our evidence provides support to the view that the establishment of the PBGC that acts as the ultimate guarantor of failed DB plans, together with a largely flat-rate premium structure, incentivizes some sponsors to take excessive risk when plan terminations become foreseeable.

JEL Classification: G11; G30; G32

Keywords: Risk shifting; Pension asset allocation; Financial distress; Moral hazard

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1. Introduction

With an increasing number of large corporations unloading their severely underfunded pension plans to the Pension Benefit Guaranty Corporation (PBGC), and the PBGC reporting a record deficit (Kozlowski, 2013), the private-sector pension system in the U.S. has received wide attention over the past decade. The PBGC, which acts as the ultimate guarantor of failed defined benefit (DB) plans, currently implements a premium structure that does not adequately reflect the riskiness of the expected future claims from plan terminations.[1] As a result, distressed firms have incentives to (1) scale back their pension contributions, and (2) aggressively invest their pension assets to gamble for a narrowing funding gap should they survive through the financial distress. In the worst case, they offload such "excess baggage" to the PBGC (Brown, 2008).

The moral hazard problem in the pension setting was first analyzed more than three decades ago by Sharpe (1976). Sharpe demonstrates that the contract between a plan insurer (i.e., the PBGC) and a plan sponsor is essentially the transfer of a put option written on the sponsor's pension assets with a strike price equal to the amount of the sponsor's pension obligations, exercisable only in the event of the sponsor's bankruptcy. However, the cost of the PBGC option is not fully aligned with its economic value, as the insurance premium charged is largely flat and only partially adjusted for pension underfunding. As a result, firms approaching bankruptcy have incentives to underfund their DB plans and invest the plan assets in risky securities.

Consistent with this theoretical framework, some studies show that firms make less or little contribution to their DB plans when their default risk is high (Coronado and Liang, 2006; Cheng and Michalski, 2010). However, whether distressed firms engage in an aggressive investment strategy to shift risk remains an open question. So far, empirical evidence on such

[1] For the year of 2013, all single-employer pension plans pay a flat-rate premium of $42 per participant per year. Underfunded pension plans pay an additional variable-rate charge of $9 per $1,000 of unfunded vested benefits.

risk shifting behavior is weak and mixed. A number of studies find a negative relation between firm risk and pension investment risk (e.g., Friedman, 1983; Petersen, 1996; Rauh, 2009), thus consistent with the presence of risk management rather than risk shifting incentives, but there is also some sketchy evidence that firms with the most valuable PBGC puts invest their pension funds in riskier assets (Bodie, Light, Morck, and Taggart, 1985; Coronado, Liang, and Orszag, 2006). In this paper, we re-examine if risk shifting is present in pension investment.

We posit that firms weigh the benefits and costs when they make decisions about whether to engage in risk shifting. The PBGC insurance, being essentially a put option on the sponsor's pension assets, increases in value with the volatility of the pension investment. If a riskier pension portfolio realizes a high return, the sponsor will benefit from improved pension funding. If, instead, the pension investment reports a poor performance, depending on the sponsor's financial health, it could pose a significant cost to the sponsor. One the one hand, if the sponsor goes bankrupt, the put option will be exercised and the PBGC will bear the consequence of the poor performance. On the other hand, should the sponsor stay in business, the put option is not exercisable, and the firm may need to drain cash from its normal business to compensate the worsened pension funding (Rauh, 2009). Following this argument, we expect that for the potential benefits from risk shifting to outweigh the costs, two necessary conditions need to be met. First, the PBGC put option is only exercisable in the event of bankruptcy of the sponsors. Therefore, high ex-ante bankruptcy risk is a necessary condition to trigger risk shifting in pension investment. Second, even when a sponsor is in financial distress, the PBGC put option is deeply out of money if their DB plans are adequately funded. In such cases, taking excessive investment risk in the hope of further improving the funding status brings in little short-term benefit as the Employee Retirement Income Security Act (ERISA) prohibits pension surplus withdrawal.[2] Thus, severe plan underfunding is the second necessary condition for risk shifting. When both conditions are met, aggressive gambling by investing heavily in risky securities could result in a high return on pension assets, leading to a shrinking funding gap and lower future mandatory pension contributions. If things go sour, the downside would be likely picked up by the PBGC given the sponsor's high bankruptcy risk.

What if these two conditions are not met? We argue that firms in the other extreme, i.e., firms with well-funded DB plans whose bankruptcy risk is extremely remote, will also derive a net benefit from increasing the volatility of their pension assets, because the cost arising from a poor performance of the pension investment becomes negligible. Given that the plans are well funded, the poor performance may not immediately put a drain on corporate cash. For an average firm, however, the cost of risky investment will be higher than those in the two extremes, and hence they may be inclined to follow a more conservative strategy in pension investment.

Our approach is significantly different from prior studies in the following manners. First, we stress the presence of both financial distress and funding inadequacy is necessary for risk shifting to take place. With a few exceptions, most of the previous studies separately analyze their effects. We show that the lack of evidence of risk shifting in these studies can be partly explained by their focus on the two conditions individually. For the few extant studies that have considered the joint effect of financial distress and funding level on pension asset allocations (e.g., Coronado and Liang, 2006; Coronado, Liang, and Orszag, 2006; Anantharaman and Lee, 2014), their research design does not take into account how healthy firms with adequately funded plans may also have incentives to increase pension investment risk. We take a step forward to employ a model that allows a non-linear relationship between pension investment risk and the

[2] ERISA and the Internal Revenue Code allow access to surplus pension assets only in certain restricted circumstances. In the event of sponsor bankruptcy, a pension asset reversion on plan terminations is subject to corporate income tax and also an excise tax as high as 50%.

joint effect. Second, we analyze how pension asset allocation *changes* in response to changes in its determinants, to supplement a pooled analysis of pension asset allocation *levels*. Extant studies primarily provide evidence at a pooled cross-sectional level only.

We download data from Compustat for all public companies sponsoring DB plans for the period 2003-2011. We rank all observations into quintiles of funding level and financial health separately according to their global position over the entire sample period, and investigate how those in the intersection of the lowest quintiles of both metrics invest their pension assets. We find that sponsors with the worst funding status and highest bankruptcy likelihood hold a larger share of equities relative to an average firm. The analysis of changes in pension investment shows that firms actively tilt their pension portfolio toward risky equities when both financial health and funding level worsen. Our results are consistent with the presence of risk shifting behavior in pension investment. We also find some evidence that healthy firms with well-funded plans take more pension investment risk than an average firm in the pooled cross-sectional analysis, supporting our hypothesis that the relationship between pension investment risk and the joint effect of funding level and survival probability is non-linear.

We conduct a few additional analyses to gauge the robustness and gain further insights of our results. First, we take advantage of a unique opportunity presented by the subprime financial crisis in 2007-2008 when a large number of firms crossed the threshold where risk shifting becomes optimal. We find that firms actively shifted pension assets to equities when both funding level and financial health worsened during the financial crisis. Second, we use an alternative predictor of bankruptcy to ensure that our results are not driven by our proxy for financial health and obtain similar results. Third, we find a significant decline in risk shifting behavior among DB plan sponsors in the U.K. when the Pension Protection Fund (PPF) started implementing a risk-adjusted premium in 2006. Finally, we find that firms filing for distress terminations of their DB plans invested more of their pension assets in equities in the last two years before the terminations took place, relative to a set of matched firms, as well as firms that filed for standard terminations. Overall, our results provide compelling evidence of risk shifting among financially distressed firms with severely underfunded DB plans.

We contribute to the extant literature on risk shifting by examining this phenomenon in the pension context. Despite the theoretical foundation of risk shifting in the literature, so far empirical evidence on such behavior is limited. Some recent studies explain that distressed firms may find it hard to shift risk due to financing difficulty or protective covenants imposed by creditors (Boyle and Guthrie, 2003; Nini, Smith, and Su, 2009). Pension investment is an alternative setting that circumvents the issue of funding constraints, since managers can shift risk by increasing the volatility of the existing pension assets.

Our study also contributes to the ongoing discussion about the PBGC reform. The current PBGC pension insurance contains little risk adjustment, and this structural flaw may encourage excessive risk taking by some plan sponsors (Brown, 2008). Although we show that risk shifting is only triggered in specific scenarios, such behavior has a direct and significant impact on the financial position of the PBGC. Any further deterioration of the financial vulnerability of the PBGC raises the possibility of a taxpayer bailout of significant magnitude. Currently, the agency is considering a redesign of its premium structure to curb moral hazard due to the insurance mispricing. Our findings provide supporting evidence to the PBGC reform.

The rest of the paper proceeds as follows. The next section reviews the relevant literature and institutional background. Section 3 discusses the sample and presents the research design. Sections 4 and 5 present the results and additional tests. Finally Section 6 concludes.

2. Literature Review and Institutional Background

Risk shifting, also known as asset substitution, occurs when shareholders increase the riskiness of the firm's business to maximize shareholders' value at the expense of debtholders' interests. Theoretically, risk shifting is expected to be especially severe among distressed firms, but empirical evidence from prior studies is limited (Andrade and Kaplan, 1998; Parrino and Weisbach, 1999; Graham and Harvey, 2001; Eisdorfer, 2008; Purnanandam, 2008).

In the pension context, the PBGC is similar to an unsecured debtholder with a relatively low priority in bankruptcy claims. If a firm enters bankruptcy with insufficient pension assets to fulfill its pension obligations, the PBGC will take over its pension assets, and provide plan recipients with their annual pensions up to a statutory maximum amount.[3] Sharpe (1976) first demonstrates that this arrangement is equivalent to sponsors holding a put option exercisable in the event of bankruptcy. This put option, if incorrectly priced, may incentivize firms to engage in risk shifting by underfunding their pension plans and investing the plan assets in risky securities.

In an insurance setting, there is some empirical evidence in the bank and thrift industries that the establishment of deposit insurance leads to banks taking a riskier loan portfolio (Cole, McKenzie, and White, 1995; Hooks and Robinson, 2002). Nonetheless, evidence on such moral hazard problem in the pension setting is diverging and conflicting. With respect to pension funding, some studies show that firms with poor credit ratings or high risk contribute less and therefore have more underfunded plans (e.g., Friedman, 1983; Coronado and Liang, 2006; Cheng and Michalski, 2010), but Francis and Reiter (1987) and Petersen (1996) find that higher firm risk is associated with better pension funding.

Concerning pension investments, two competing theories, risk shifting vs. risk

[3] For single-employer plans terminated in 2013, workers who retire at age 65 can receive up to $57,477.24 per year.

management, attempt to explain firm incentives and provide different predictions.[4] The risk shifting incentive, based on Sharpe's theory, implies that sponsors with a nontrivial probability of bankruptcy invest more in risky securities. Although theoretically appealing, the empirical evidence supporting risk shifting is weak and mixed. Bodie, Light, Morck, and Taggart (1985) find a negative relation between pension risk and funding position but only among the riskiest firms. Similarly, Coronado, Liang, and Orszag (2006) find limited evidence that U.S. firms becoming riskier increase the share of equity assets in their pension portfolio by a small increment. Yu and Zhang (2010) find no evidence supporting the risk shifting hypothesis.

Another line of the literature provides evidence consistent with the risk management hypothesis: firms with high leverage, volatile earnings, poor bond ratings, or volatile cash flows invest their pension assets more conservatively (Friedman, 1983; Bodie, Light, Morck, and Taggart, 1985; Amir and Bernatzi, 1999). Rauh (2009) further finds that firms with underfunded plans or poor credit ratings invest less in risky securities. Collectively, these studies show that firms balance their pension portfolio to manage rather than shift risk. A few recent studies link the risk taking incentives in pension investment with corporate governance and managerial compensation structure (Phan and Hegde, 2013; Anantharaman and Lee, 2014).

Although the empirical evidence on pension risk shifting is weak, regulators and standard setters have taken actions to mitigate the pension dumping problem. The Financial Accounting Standards Board (FASB) issued FAS No. 132 (revised) in 2003, requiring disclosure of information on each major category of plan assets at the broadest level. After a few shocking pension failures (Belt, 2005), the Pension Protection Act was signed into law in August 2006, imposing more stringent funding requirements on DB plans. Further, FASB issued Staff Position in December 2008, requiring firms to provide a more refined breakdown of pension asset

[4] Tax benefit maximization is another incentive behind pension investment decisions (Black, 1980; Tepper, 1981).

categories in footnote disclosure and explain how pension allocation decisions are made.

The above reforms take place concurrently with a deteriorating financial condition of the PBGC. The agency reported a deficit of $36 billion in 2013, the largest in the PBGC's 40-year history. Both researchers and practitioners have pointed out that the PBGC premium fails to properly price the underlying risk of the sponsors and their pension plans, thus encouraging excessive risk taking and pension dumping by sponsors (Belt, 2006; Brown, 2008; Snowbarger, 2011). In November 2012, the U.S. Government Accountability Office issued a report advising that the premium structure be redesigned to better align rates with risks from sponsors, including plan underfunding risk, the sponsor's financial strength, and/or plan investment strategy.[5]

Against this backdrop, we re-examine the risk shifting hypothesis in the pension setting. We assess the tradeoff between the costs and benefits of risky pension investment to identify a scenario in which the risk shifting incentive is most likely to be triggered. We argue that while all firms benefit from increasing the volatility of the plan assets due to the option nature of the PBGC insurance, firms bear different levels of costs from holding a risky pension portfolio.

For financially constrained firms, the probability of their PBGC put option becoming exercisable is high. However, if their plans are well funded, these firms find it unnecessary to unduly increase the riskiness of the pension assets for two reasons: (1) even if the gamble succeeds, the pension surplus cannot be reverted to the sponsors to lessen their financial distress problem, but a failed gamble may worsen the funding position and deepen their financial distress; (2) the pension surplus can be reverted to the sponsors on their bankruptcy but subject to corporate income tax and a high excise tax. If, instead, concurrently the plans are underfunded, the option is in the money, and hence shifting risk to the PBGC by investing the pension assets

[5] The report is available at http://www.gao.gov/products/GAO-13-58.

aggressively becomes optimal. With difficulty to access the capital market for additional funding and pressure for mandatory pension contributions, these firms have incentives to hold a risky pension portfolio. If the gamble succeeds and the firm avoids bankruptcy, the potential high return on risky pension assets could result in a reduced funding gap and lower mandatory contributions in the future (Rauh, 2009). In the event of bankruptcy, the realized performance of the pension investment becomes irrelevant for the sponsors as the PBGC or beneficiaries have to assume the consequences of any funding shortfall when the PBGC option is exercised. Thus, we emphasize that both conditions – sufficiently high bankruptcy risk and severe pension underfunding – need to be met to induce the risk shifting behavior in pension investment.[6]

For financially sound firms, the chance of filing for bankruptcy is small and their PBGC put option is far from exercisable. If their plans are severely underfunded, the cost of a potential poor realized performance of risky pension investment is high due to the required deficit reduction contribution by ERISA. However, if their plans are well funded, the cost is relatively low as there is sufficient funding for the pension liabilities. Therefore, these healthy firms also have incentives to increase their risk taking to earn a higher expected return in the long run given the long-term nature of pension obligations (Addoum, Binsbergen, and Brandt, 2010).

3. Sample Selection and Research Design

Our sample is drawn from all U.S. public firms with necessary pension and financial data available in the Compustat fundamental and pension annual files. We limit our sample to 2003-2011 because data on pension asset allocations are available on Compustat only after 2002. After

[6] Not all DB plans sponsored by financially distressed firms are severely underfunded. Generous contributions in the past good times, effective fund management, or pressure from strong labor unions, could all contribute to a sound or reasonable funding position. According to the PBGC, for Chapter 11 bankruptcy filings, many plan sponsors emerge from the reorganization process without terminating their plans.

excluding all firm-years with missing data, our final sample comprises 9,472 observations representing 1,529 unique firms.

Pension assets are categorized into equities, debts, real estates, and others in Compustat pension data file. We construct two variables to measure pension investment risk: percentage of pension assets allocated to equities and percentage of pension assets allocated to debts. We calculate pension funding level as the market value of pension assets over projected benefit obligation. To measure bankruptcy risk, we obtain probability of default estimates from the Risk Management Institute (RMI) at the National University of Singapore. RMI adopts a forward intensity approach to evaluate the probability of default, and has made public these estimates together with model inputs since 2009 (Duan and Van Laere, 2012; Duan, Sun, and Wang, 2012).[7] As a robustness check, we also estimate the probability of default using Shumway's (2001) hazard model modified by Campbell, Hilscher, and Szilagyi (2008).

In our main analysis, we use the 12-month-forward probability of default from RMI to measure bankruptcy risk. For ease of exposition and interpretation, we convert probability of default into survival probability, which equals one minus probability of default. We investigate how the joint level of plan funding and sponsor survival probability affects a firm's pension investment decision.

Since we predict that firms in both extremes of the joint effect are more likely to take greater pension risk, we construct a model that allows for a non-linear relationship between pension investment and the interaction of funding level and survival probability, by creating dummy variables that represent different permutations of the interaction.

[7] A forward intensity approach is an extension of the Poisson intensity model (Duffie, Saita, and Wang, 2007) which is built upon instantaneous intensity. One of the advantages of the forward intensity approach over the traditional Poisson intensity approach is that for the purpose of multiperiod default prediction, it models the forward rate of event occurrence directly using data known at the time of prediction, and avoids the need to estimate the high-dimensional time-series dynamics of the state variables as in the traditional model.

$$\% \, allocation = \sigma_0 + \sum_{j=1,k=1}^{5} \beta_{jk} \, Interaction_{jk} + \sigma_1 Pension \, size + \sigma_2 Pension \, life \, cycle + \sigma_3 \, Open/Frozen \, status + \sigma_4 Reporting \, regime + \sigma_5 Effective \, tax \, rate + \sigma_6 Leverage + \sigma_7 Firm \, size + year \, fixed \, effects + \varepsilon \quad (1)$$

% allocation is the percentage of pension assets allocated to equities or debts. $Interaction_{jk}$ are dummy variables that are constructed to capture the combined effect of $Funding\ level_j$ and $Survival\ probability_k$, the two necessary conditions for risk shifting. We first pool all firm-year observations and perform a global sort of funding level and survival probability into quintiles separately, and then interact the quintiles to form 25 different combinations. We regress pension asset allocations on these interaction indicator variables and a set of control variables. To facilitate interpretation and a subsequent analysis of changes, we then transform this model into a parsimonious one with 14 dummy variables (*Interaction=N*, where N takes one of the 14 unique interaction values) by grouping observations with the same quintile interaction value together.[8] [9] For example, we use *Interaction=6* to represent the interaction of the second funding level quintile and the third survival probability quintile, or the third funding level quintile and the second survival probability quintile.

The way we sort funding level and survival probability into quintiles may need some explanation. We argue in favor of a global sort to an annual relative sort because it is the absolute rather than relative level of a firm's pension funding position and financial health that determines if risk shifting is optimal. For example, if the probability of financial distress for all firms in a particular year is remote, none of them will have the incentive to shift risk. Credit rating agencies also assign credit ratings by evaluating a firm's performance relative to a rich history of all firms'

[8] There are 25 (= 5 × 5) different combinations of the funding level quintiles and survival probability quintiles that generate 14 unique numerical values – 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 16, 20, 25.
[9] By constructing the interaction indicator variables this way, we implicitly assume that the impact of funding level on pension asset allocations is of equal strength as that of survival probability.

past performance, rather than ranking firms among their peers in a specific year. Our sample period encompasses periods of financial boom and financial crisis, which provides an excellent platform for us to obtain a wide variation in firms' pension funding level and financial health to examine the presence of risk shifting.

Following the existing literature, we control for other determinants of pension asset allocations. We divide the control variables into three categories: pension-plan characteristics (past investment return, pension size, pension life cycle, and open/frozen status), pension reporting regime, and firm characteristics (effective tax rate, leverage, and firm size). First, since investment performance in the previous period can affect pension allocation in the current year due to behavioral inertia in investing or cost of rebalancing (Rauh, 2009), we control for the actual return on pension assets in the immediate prior year (*Past investment return*). Next, we control for the materiality of pension plans (*Pension size*), measured as projected benefit obligation over total firm assets. We include the pension investment horizon (*Pension life cycle*), measured as the ratio of current benefit payment over projected benefit obligation. More mature plans have higher current benefit payments, and therefore relatively short investment horizons. Many DB plans are frozen in recent years (Comprix and Muller, 2011), and sponsors of these plans are more inclined to invest conservatively. We include a dummy variable (*Open/frozen status*) to reflect whether the pension plans are frozen. If the reported service cost is zero, *Open/frozen status* takes the value of one, and zero otherwise.

Amir, Guan, and Oswald (2010) find that firms shift their pension assets from equities to debts following the adoption of a new pension standard (SFAS 158) which requires the full recognition of pension funding status for fiscal years ending on or after Dec 15, 2006. Hence, we include a dummy variable *Reporting regime* to capture this change in the reporting regime.

Reporting regime takes the value of one if the fiscal year end is on Dec 15, 2006 or after, and zero otherwise. We also control for the tax status of the sponsor (*Effective tax rate*), measured as tax expense over pre-tax income, since there are tax-based incentives in pension investment.[10] Finally, we include two variables to capture firm-specific characteristics: financial leverage (*Leverage*), which is measured as long-term debt divided by total firm assets, and *firm size*, measured as the natural logarithm of total firm assets. We also include year fixed effects to address the concern of an over-time shift in the average pension asset allocation.

4. Empirical Results

Table 1 summarizes the descriptive statistics of the variables in our main analysis. Panel A shows that on average firms allocate more pension assets to equities (58.034%) than debts (38.872%). This is consistent with the percentages reported in prior studies using firm-level data (e.g., Table 4 in Rauh (2009)). Most firms have underfunded pension plans – the median value of funding level in our sample is 78.8% and the lowest is 26.2%. Our sample firms are mostly financially healthy, as would be expected for publicly listed companies. The probability of default, equal to one minus survival probability, is less than 1% on average. The highest probability of default among all sample observations is 78.8% (= 1 – 21.2%).

For the set of eight control variables, *past investment return* takes a mean (median) value of 7.3% (9.8%). Both values are comparable to the average annual calendar return of the S&P 500 Index over the sample period at around 8%. *Pension size* has a mean (median) of 14.8% (8.5%), indicating that pension liabilities are often sizable. *Pension life cycle* measures the plan maturity, and a newly established plan with more active participants will take a smaller value

[10] In an untabulated test, we also use marginal tax rate (Blouin, Core, and Guay, 2010) in lieu of effective tax rate. The results remain similar.

relative to a mature plan with more retirees. Our sample firms have a mean (median) pension life cycle of 5.1% (4.7%). Despite an increasing number of sponsors freezing existing pension plans, 90% (= 1 – 10%) of the pension plans of our sample firms are still open to new entrants or accruing pension benefits to existing participants. About 65% of our firm-year observations report under the regime that requires the full recognition of pension funding surplus/deficit. Finally, our firm characteristics metrics show that the sample firms are generally profitable (average *effective tax rate* is positive at 25.8%), not highly geared (average financial *leverage* equals 20.4%), and relatively large (average total assets approach $2.75 billion).

Panel B shows the trend of key variables for the sample period 2003-2011. Consistent with Amir, Guan, and Oswald (2010), over time the pension asset mix has tilted toward debts and away from equities. The percentage of pension assets invested in equities decreases from 61.653% in 2003 to 51.704% in 2011, a drop of nearly ten percentage points or 125 basis points per year. The allocation to debts, on the contrary, increases by nearly nine percentage points from 2003 to 2011. The increased allocation to debts does not fully offset the decreased allocation to equities, suggesting that firms in recent years allocate slightly more into alternative assets such as real estates or hedge funds (Anantharaman, 2011). Funding level increases initially and peaks at 91.2% in 2007, before a substantial decrease of nearly 20 percentage points to 72.6% in 2008, likely driven by the market nosedive during the financial crisis. Firms are financially healthy even during the period of financial crisis. The average probability of default remains low at 2.1% (1– 97.9%) in 2008. In most other years the average probability of default is less than 1%.

Panel C of Table 1 presents some key statistics of each funding level and survival probability quintile as well as their interaction value. Since we allocate the sample observations into each quintile according to their overall position in the pooled sample, it is natural to observe an increasing funding level for each funding level quintile, and an increasing survival probability for each survival probability quintile. Funding level and survival probability in general have a positive correlation but there are observations with very high survival probability in the lowest funding level quintile, and observations with very high funding level in the lowest survival probability quintile, and vice versa. Even though the distribution of the observations in the 14 interaction values is not even by construction, the minimum number of observations in any interaction value is still quite high at 375. *Interaction=1*, the joint effect of our primary interest, contains 529 observations, with the funding level ranging from 0% to 65.1%, and the survival probability from 21.2% to 99.6%.

Pooled cross-sectional evidence

We estimate Equation (1) and report the coefficient of each joint effect indicator variable in Panel A of Table 2. For ease of exposition, we leave the effect of the interaction of the two middle quintiles in the intercept and therefore all reported coefficients measure the incremental difference from this middle portfolio in their pension investment. We do not report the coefficients for the control variables and year fixed effects for brevity. Using the percentage of pension assets invested in equities as the dependent variable, the top Cartesian product table reveals that firms in the low extreme portfolio, i.e., cell (1,1), invest the most in equities among all joint effect portfolios, with an increment of 2.853 percentage points relative to firms in the benchmark portfolio. This result is consistent with our view that firms near bankruptcy with a substantial pension funding gap tend to invest their pension assets aggressively. We also observe that firms in the high extreme portfolio, i.e., cell (5,5), register the second highest allocation to equities. These financially healthy firms with adequate pension funding face little cost in the event of an unsuccessful gamble, and thus are also incentivized to hold a risky portfolio. Interestingly, the table shows that firms in the off-diagonal portfolios (i.e., cell (1,5) and cell (5,1)) allocate the least to risky equities. We draw qualitatively similar conclusions from the results in the bottom Cartesian product table in which the percentage of pension assets allocated to debts is the dependent variable.

In Panel B we report the regression results for the parsimonious model constructed by grouping observations with the same quintile interaction value together. We omit *Interaction=5* in the regressions and leave its effect in the intercept.[11] All coefficients of the joint effect indicators are positive (negative) in Model 1 (2). In particular, at both extremes the allocation to riskier (safer) equities is more than seven percentage points (five percentage points) higher (lower) than our benchmark firms, suggesting that both low extreme and high extreme firms take on more risk. The aggressive investment by the low extreme firms is consistent with risk shifting. The results are also illustrated in Figure 2a (2b), which shows a U-shape (inverted U-shape) relation between the joint effect of funding level and survival probability and the percentage of pension assets allocated to equities (debts). For comparison, we also regress pension asset allocations on funding level deciles (survival probability deciles) together with the same set of control variables and year fixed effects, and plot the coefficients of the decile indicators in Figure 1. In contrast to Figure 2, Figure 1 (drawn to the same scale) reveals a flat rather than a U-shape or inverted U-shape relation. This comparison highlights the importance to model a non-linear relationship and the necessity to recognize the joint effect of plan funding and sponsor financial health to identify risk shifting in pension investment.

With regards to the control variables, the coefficient of *past investment return* is positive

[11] We omit *Interaction=5* in our main analysis for a clear presentation of the results, because our results in Panel A show that this is the interaction value associated with the lowest (highest) allocation to equities (debts). Choosing to omit other *Interaction* dummy variables does not change our results.

(negative) and significant at the 0.01 level, indicating that firms allocate more (less) pension assets to equities (debts) when they experience a higher average return on plan assets in the immediate past. An alternative explanation is that a higher past investment return likely reflects a relatively strong equity market, leading to an increased proportion of equities compared to debts in the pension portfolio. As reflected by the negative coefficient of *pension size* in Model 2, larger plans tend to invest less in the safer debt securities. The negative and significant coefficient on *pension life cycle* in Model 1 indicates that more mature plans invest more conservatively given their shorter investment horizons and higher payouts to pensioners. Consistent with Coronado, Liang, and Orszag (2006), we find that firms facing a high tax rate hold an equity-heavy portfolio instead of a debt-heavy portfolio, suggesting that maximizing tax benefit is of secondary importance. We also find that financial leverage and firm size are significant determinants of pension risk-taking in Model 2, but not in Model 1.

Overall, the results in Table 2 demonstrate that firms have incentives to shift pension risk only when the bankruptcy risk is sufficiently high and pension plans are severely underfunded. These findings are also consistent with our hypothesis of a non-linear relation between pension asset allocations and the joint effect of plan funding level and sponsor survival probability.

Changes in asset allocations

To supplement our analyses on the *levels* of pension asset allocations in pooled cross-sectional data, we examine *changes* in pension asset allocations with respect to changes in the joint effect of funding level and default probability over two consecutive years. The dependent variable is active re-allocation to equities (debts) in Table 3. We construct this variable following the methodology employed by Brandt, Santa-Clara, and Valkanov (2009) and Addoum, Binsbergen, and Brandt (2010). The details of the extraction procedure are described in Appendix B. We use the active re-allocation component rather than simply taking the first difference between the allocations in two consecutive years because, all else being equal, the percentage of equities in a pension portfolio increases if (1) the firm actively shifts its pension assets from debts to equities, or (2) the value of equities increases relative to the value of debts in a bull stock market. We label the former reason active re-allocation and the latter passive re-allocation. The active re-allocation component is more pertinent to our study. In essence, active re-allocation is equivalent to first adjusting the asset allocation in the prior year to accommodate for passive market movements before taking the difference. We lose 1,605 observations since we require the same firm to have data over two consecutive years to compute all variables. During our sample period, active re-allocation to equities has a mean (median) of -0.99% (-0.57%), while active re-allocation to debts takes a mean (median) value of 0.93% (0.71%). We find that when *Interaction* decreases in value, i.e., when a firm moves toward the low extreme risk-shifting cell, the firm actively reallocates more (less) pension assets to equities (debts), as evidenced by the significantly negative (positive) coefficient of *ΔInteraction* in Model 1 (2). Our control variables are mostly insignificant with the exception of *ΔPension size*, which negatively determines the active re-allocation to equities, and *ΔFirm size*, which increases (decreases) the active re-allocation to debts (equities).[12]

Collectively, we provide confirmative evidence from both an analysis of levels and an analysis of changes in pension asset allocations to support our main hypothesis that risk shifting can be triggered in financially distressed firms with substantial pension underfunding.

[12] We do not control for changes in *past investment return* because it is already used in the estimation of the active re-allocation components. Including changes in *past investment return* as a control variable does not qualitatively change our conclusion.

5. Additional Tests

5.1. Financial crisis

Our sample period covers 2003-2011, which includes a period of boom, financial crisis, and recovery. As shown in Panel B of Table 1, 2008 is the year when both pension funding levels and firms' survival probabilities were significantly hampered by the crisis. This provides us a rare opportunity to investigate firms' risk shifting behavior during this unique period.

From our full sample of 1,529 unique firms, we identify a constant sample of 1,033 firms with data available in both 2007 and 2008. We then re-sort these firms into funding level and survival probability quintiles separately and construct the *Interaction* value variable using the same method as in Table 2.We extract the active re-allocation components as the dependent variables in the regressions of how firms react to the deteriorating market conditions over 2007-2008. The results in Table 4 show that increases (decreases) in *Interaction* significantly decrease (increase) risk taking. In other words, when a firm experiences a lower funding level and/or survival probability, it actively shifts more (less) pension assets to equities (debts).

In an untabulated analysis, we perform the same test of changes in every year of our sample period. Out of the eight years of changes, we observe the expected sign of the *ΔInteraction* variable five times (seven times) when the dependent variable is active re-allocation to equities (debts). A Fama-MacBeth (1973) analysis of the *ΔInteraction* variable gives a coefficient of -0.028 (0.100) for the equity (debt) regression, and statistically significant close to the 5% level for the debt regression. This additional analysis indicates that our main results are not driven by any particular year in our sample period.

5.2. Alternative proxy for financial health

There is a wide range of proxies for default risk and models for bankruptcy prediction in the academic literature, therefore our results can be sensitive to how we measure financial health. As a robustness check, we employ an alternative proxy for bankruptcy risk. We use a recent and popular model developed by Campbell, Hilscher, and Szilagyi (hereinafter CHS, 2008), which modifies Shumway's (2001) hazard model and incorporates both accounting and market variables to predict corporate failures. We retrieve the coefficients for the best reduced-form model in Table 4 of CHS (2008) to estimate the 12-month-forward probability of corporate failure, which is then converted to survival probability for ease of interpretation. The results are reported in Table 5. Similar to Panel B of Table 2, the coefficients of the joint effect indicator variables exhibit a U-shape (an inverted U-shape) relation with the share of equities (debts) in the pension portfolio. In an untabulated test, we expand the bankruptcy prediction horizon from 12 months to 24 months, using both the RMI and CHS measures. Our key results remain robust, adding further confidence to our previous findings.

5.3. U.K. Evidence

The PPF, the PBGC's counterpart in the U.K., was established in April 2004, and became functional in 2005. For the first fiscal year 2005-2006, the premium charged was a flat rate solely dependent upon the number of plan participants. Since April 2006, the PPF has collected two different types of premiums: a scheme-based premium proportional to the size of the insured pension liabilities (capped at 20% of the total collected premium); and a risk-based premium that takes into account the sponsor's insolvency risk and plan underfunding risk (minimum set at 80% of the total collected premium).[13] From fiscal year 2012-2013 onward, the risk-based

[13] The PPF also collects an administration premium and a fraud compensation premium. More details about the PPF premium can be obtained from: http://www.pensionprotectionfund.org.uk/levy/aboutlevy/Pages/AbouttheLevy.aspx

premium also incorporates pension investment risk in estimating funding level.

We use this interesting setting to further test the validity of our main argument. Our evidence so far shows that the PBGC, taking over failed DB plans but charging a largely flat-rate premium, instigates risk shifting under specific conditions. As the premium charged by the PPF since 2006 has priced in the two necessary factors that lead to risk shifting in pension investment – funding shortfall and insolvency risk, we expect the risk shifting incentive to be weaker or absent among the U.K. firms after 2006 relative to the period before. To empirically test this conjecture, we retrieve a U.K. sample for the period 2003-2011 from Datastream, consisting of 2,477 firm-year observations that sponsor DB plans, and perform the same analysis as in Panel B of Table 2. We label 2003-2005 the "before" period and 2006-2011 the "after" period. We obtain PD data from RMI and sort funding level and survival probabilities into quintiles within each sub-period to construct the *Interaction* value variable. We include an indicator variable *After*, taking the value of one for the "after" period (2006-2011), and zero otherwise, and then interact it with the set of joint effect indicator variables as well as all control variables. We exclude pension life cycle and reporting regime in the control variables because the data on the former are not available, and the effect of the reporting regime change is largely picked up by the indicator variable *After*.[14]

Our results are shown in Table 6. In the "before" period, firms with the lowest funding level and the lowest survival probability (i.e., *Interaction=1*) register the highest share of equities in their pension portfolios, and firms with the highest funding level and the highest survival probability (i.e., *Interaction=25*) register the lowest share of equities. We view this as evidence

[14] In the U.K., it has been required to recognize pension funding surplus/deficit on the balance sheet since January 2005.

of risk shifting when the PPF premium is not adjusted for risk.[15] Focusing on the "after" period, the coefficient of *Interaction* × *After=1* in Model 1 is significantly negative at the 0.10 level, indicating a reduced deviation of the low extreme firms (i.e., *Interaction*=1) from benchmark firms (i.e., *Interaction*=5) in terms of their risk taking. To be more specific, relative to the benchmark firms, the low extreme firms in the "before" period allocate 11.532 percentage points more pension assets to risky equities, while this increment decreases to only 2.649 (=11.532-8.883) percentage points in the "after" period. As expected, the results of Model 2 based on pension assets allocated to debts reveal an opposite trend.

We further plot the coefficients of the interaction indicators for the "before" and "after" period respectively using *Interaction=5* as the benchmark. Figures 3a and 3b show that the allocation curve is flattened considerably in the "after" period, suggesting that the risk-shifting incentive is weakened under a risk-adjusted premium scheme. Our results based on the U.K. data corroborate the evidence that premium mispricing can be an important trigger of risk shifting in the U.S. DB pension investment, and that a correction of the mispricing can mitigate the moral hazard problem.

5.4. PBGC Terminations

So far our attempt to identify the risk-shifting scenario depends, to a large extent, on the proxies we use to measure funding level and bankruptcy risk. We note that bankruptcy can be challenging to predict and the measurement of funding level is subject to actuarial assumptions. In this section, we attempt to circumvent this problem by using DB plan termination data obtained directly from the PBGC.

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[15] We conjecture that firms may start shifting risk in 2003 when they anticipate the setting up of the statutory insurer in 2004 without a foreseeable risk-adjusted premium structure.

There are two types of DB plan terminations through the PBGC: standard terminations and distress terminations. A plan that has sufficient assets to pay all promised pension benefits may be voluntarily terminated as a standard termination. The sponsor can either purchase an annuity from an insurance company or pay the benefits in a lump sum. A distress termination takes place when a sponsor enters bankruptcy with insufficient pension assets to cover its pension obligations and the PBGC becomes the trustee.[16] These two types of firms, standard termination firms and distress termination firms, are particularly pertinent to our research question. Relatively speaking, standard termination firms are financially sound and their plans are well funded; distress termination firms are financially distressed and their plans are underfunded. Hence, the standard termination firms can serve as a natural benchmark to the latter, and allow us to examine if the latter have invested their pension assets more aggressively.

Panel A of Table 7 reports the number of public firms that have DB plans terminated during 2003-2011. In our sample period, 91 (74) public firms applied for standard (distress) terminations. We identify a constant sample of firms that have asset allocation data in all three years before their terminations and compare the allocation between these two groups in Panel B. We notice that some firms may not terminate all their sponsored DB plans, and including them in the sample may garble our results given that Compustat provides only firm-level pension allocation data. So additionally we analyze a sample which terminated all their DB plans.[17] We conduct a t-test to examine if pension asset allocation differs between these two termination groups.[18] Our results show that three years before the terminations take place, the standard and

[16] A number of firms go bankrupt with sufficient pension assets to cover pension obligations for their DB plans. If these plans are also terminated, they are excluded from the set of distress termination firms.
[17] We have 52 (30) firms that terminated some of or all their DB plans under standard (distress) terminations, and 33 (21) firms that terminated all their DB plans under standard (distress) terminations.
[18] We also conduct a Wilcoxon rank sum test to examine if the median pension asset allocation is significantly different between the two termination groups. The results are similar and unreported for brevity.

distress termination firms are not statistically different in terms of their pension risk taking. However, the distress termination firms substantially increase (decrease) their pension investment in equities (debts) nearer bankruptcy relative to the standard termination firms. To ensure that our results are not driven by the timing of the terminations, we examine the distribution of the termination years for these two termination groups and observe no clustering of distress terminations (standard terminations) in peak (bottom) stock market years.

To address the concern that the standard termination firms are not comparable to the distress termination firms due to differences in their fundamentals, we identify another set of benchmark firms by matching the distress termination firms with firms that did not terminate DB plans by year, two-digit SIC code, and firm size (measured by total firm assets). The results in Panel C show that, relative to the matched firms, the distress termination firms are not significantly different in their pension investment two or three years before their plan terminations. When bankruptcy becomes a looming possibility, however, we observe some evidence of risk shifting as the distress termination firms substantially increase their pension risk taking.

To gain further insights from the PBGC terminations, we also examine three representative cases in which the firms filed for bankruptcy and DB plan terminations during our sample period. They are Delphi Automotive PLC., Milacron Inc., and United Airlines Inc. in Table 8. We report all years of their pension asset allocation data available on Compustat until their terminations with the PBGC. We also report the average pension asset allocations of their peers in the same two-digit SIC code that did not undergo a PBGC termination as a benchmark. The data reveal an increasing (decreasing) trend in the percentage of pension assets allocated to equities (debts) relative to their industry peers for both Delphi Automotive and Milacron. For

United Airlines we observe the same pattern but acknowledge that the number of years with available data is very limited to make a solid conclusion. In sum, we conclude that firms ending up in distress terminations of their DB plans take on more risk to gamble their pension assets prior to their subsequent bankruptcy.

6. Conclusions

A few high-profile pension failures over the past decade have directed the public's attention to the moral hazard problem under the current statutory insurance arrangements for DB plans. The PBGC, a government agency which assumes the assets and liabilities of insolvent plans, is currently facing a huge deficit. To tackle the agency's increasing financial burden, there have been calls to reform the PBGC premium structure. A premium that takes into account the risk to which the insurer is exposed is vital to the success of any insurance scheme, and it has been suggested that pension insurance premiums should account for the likelihood of sponsor's bankruptcy, the extent of pension plan's underfunding, and the risk inherent in the pension investment mix (Stewart, 2007). Failing to do so, sponsors may have incentives to shift risk to the insurer.

In this study, we examine whether the public's concern about the potential moral hazard is valid. We argue that the simultaneous presence of financial distress and plan underfunding can trigger risk shifting in pension investment. Under such circumstances financially constrained firms have incentives to gamble for resurrection and alleviate the pension contribution pressure from their severely underfunded plans. We find evidence supporting this view in both level and change settings. In addition, our analyses using the PBGC terminations data provide further corroborative evidence. We also find that the risk shifting incentive is curbed in the U.K. when the insurance premium incorporates both the sponsor insolvency risk and plan underfunding risk.

Our paper adds to the literature by providing evidence of risk shifting in the pension context. We highlight that the benefits of risk shifting outweigh its costs in an extreme condition when firms are financially distressed and their DB plans are severely underfunded. Our study has implications for the heated debate on the PBGC reform since the PBGC's premiums have not fully reflected the risks against which the PBGC insures. A premium structure into which sponsor’s financial strength, plan funding status, and plan investment mix are incorporated, as is currently implemented in the U.K., may help mitigate risk shifting and cross-subsidization between low-risk and high-risk sponsors.

Appendix A: Variable definitions

Variable	Description
% allocation	Percentage of pension assets allocated to equities or debts.
Funding level	Funding level of pension plans, measured as pension assets over projected benefit obligation.
Survival probability	Survival probability of plan sponsor, measured as one minus the 12-month-forward probability of default. The probability of default data are obtained from the Risk Management Institute at the National University of Singapore.
Interaction	Interaction value of the *Funding level* quintile and *Survival probability* quintile, taking 14 unique values, namely, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 16, 20, or 25.
Interaction=N	An indicator variable for each unique *Interaction* value, where N equals 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 16, 20, or 25.
Past investment return	Actual return deflated by beginning pension assets.
Pension size	Projected benefit obligation divided by total firm assets.
Pension life cycle	Current pension payment to projected benefit obligation.
Open/frozen status	An indicator taking the value of one if service cost is zero, and zero otherwise.
Reporting Regime	An indicator variable taking the value of one for fiscal years ending on or after Dec 15, 2006, and zero otherwise.
Effective tax rate	Tax expense to pretax income.
Leverage	Long-term debt to total firm assets.
Firm size	Natural logarithm of total firm assets.

Appendix B: Active asset re-allocation

We calculate active re-allocation in two asset classes (equities and debts) following Addoum, Binsbergen, and Brandt (2010). We assume that decision makers actively rebalance their pension portfolios each year.

Suppose that at the beginning of year *t*, decision makers discuss the investment strategy and the percentage of each asset class is set to the optimal level $w_{i,t-1}$. At the end of year *t*, the decision makers observe: 1) the actual rate of return on each asset class $r_{i,t}$; 2) the actual rate of return of the whole portfolio $r_{p,t}$; 3) the intermediate percentage of each asset class before any rebalancing trades occur $w_{i,t}^{passive}$. Mathematically, $w_{i,t}^{passive}$ can be expressed as:

$$w_{i,t}^{passive} = w_{i,t-1} * \frac{1 + r_{i,t}}{1 + r_{p,t}}$$

Subsequently, the decision makers reset the asset allocation to the optimal level $w_{i,t}$ based on the market conditions and other considerations at the end of year *t*. Therefore we define the active re-allocation in asset class *i* as below:

$$w_{i,t}^{active} = w_{i,t} - w_{i,t}^{passive}$$

We obtain the data on $w_{i,t-1}$, $r_{p,t}$ and $w_{i,t}$ from Compustat. Since the actual rate of return on each asset class $\mathrm{r}_{\mathrm{i,t}}$ is not directly observable, we choose the following benchmark indexes for each asset class.

Asset Class	Return Index	Datastream Mnemonic
Domestic Equities (80%)	S&P500 w/Dividend	S_PCOMP
International Equities (20%)	MSCI World ex-US Index	MSWXUSL
Government Debts (20%)	JP Morgan US Government Bond Index	JPMUSU
Corporate Debts (80%)	Merrill Lynch US Domestic Index	MLDOMEM

The index data are downloaded from Datastream. To simplify, we assume 80% domestic equity plus 20% international equity to construct the index return for asset class "equities". For the index return for asset class "debts", we assume 20% government debts plus 80% corporate debts.

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Figure 1: Effect of funding level or financial health on pension investment

Figure 1a plots the average percentage of pension assets allocated to equities vs. *Funding level* deciles or *Survival probability* deciles. Figure 1b plots the average percentage of pension assets allocated to debts vs. *Funding level* deciles or *Survival probability* deciles. The data used in the figures are obtained from regressing pension asset allocations on the decile dummy variables, control variables, and year fixed effects. See Appendix A for variable definitions.

Figure 1a

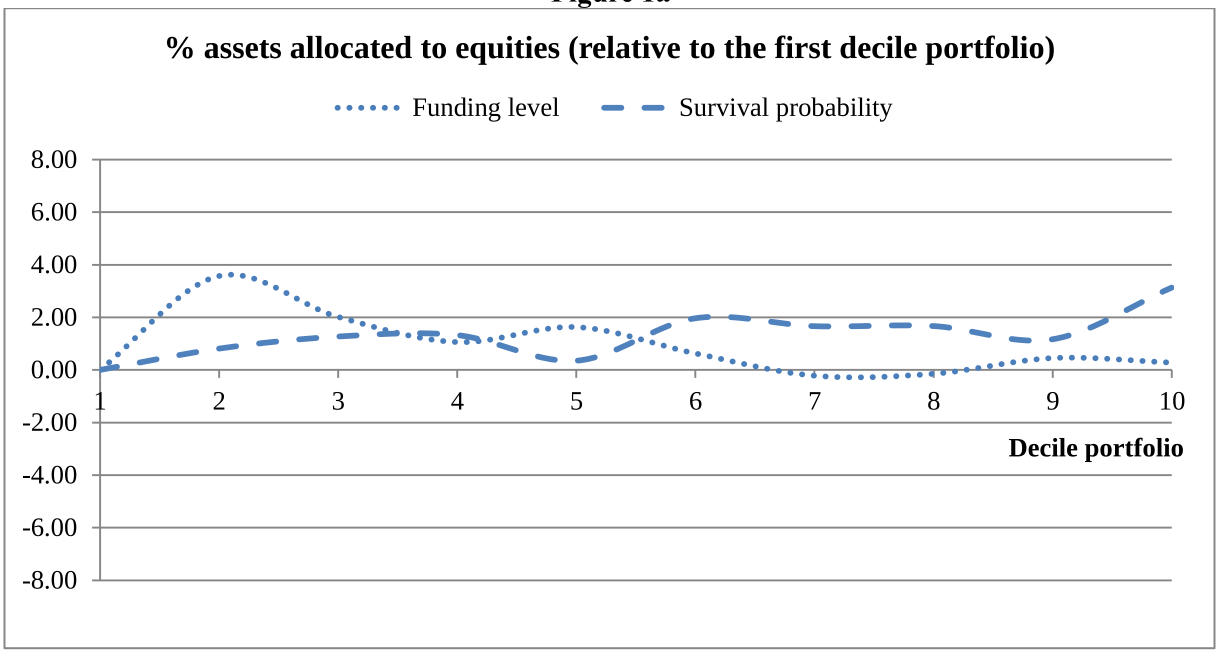

Figure 1b

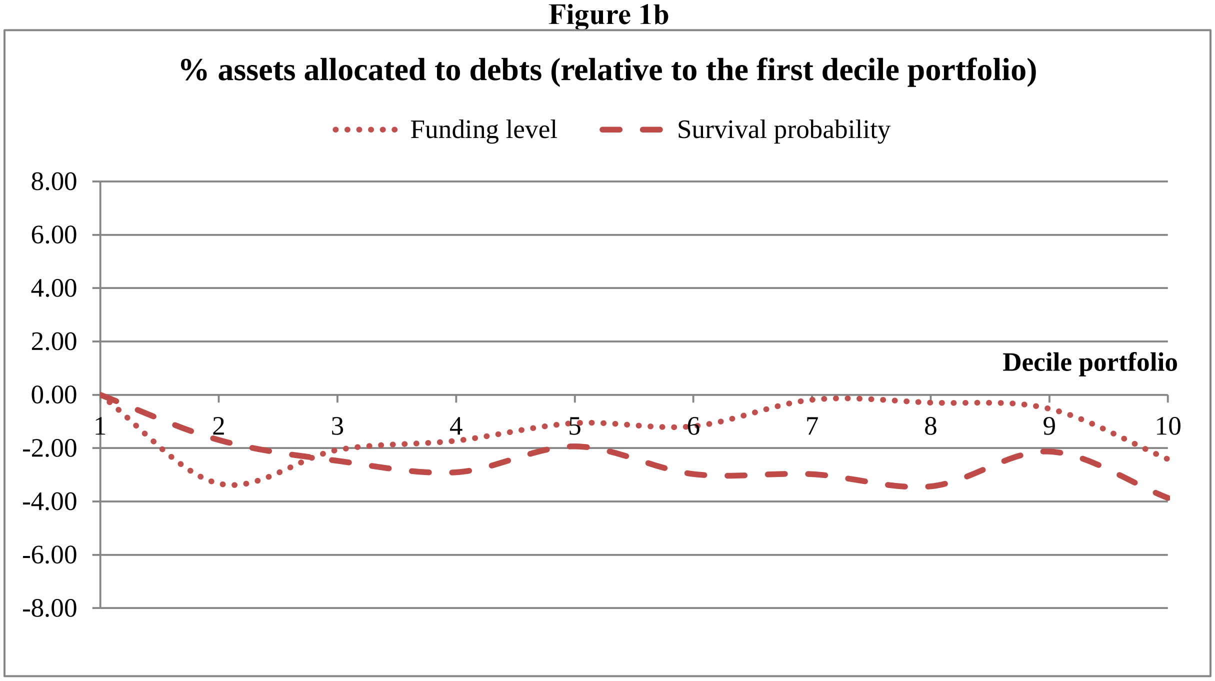

Figure 2: Joint effect of funding level and financial health on pension investment

Figure 2a plots the average percentage of pension assets allocated to equities vs. the interaction value of *Funding level* quintiles and *Survival probability* quintiles. Figure 2b plots the average percentage of pension assets allocated to debts vs. the interaction value of *Funding level* quintiles and *Survival probability* quintiles. The data used in the figures are obtained from the regression results in Table 2. See Appendix A for variable definitions.

Figure 2a

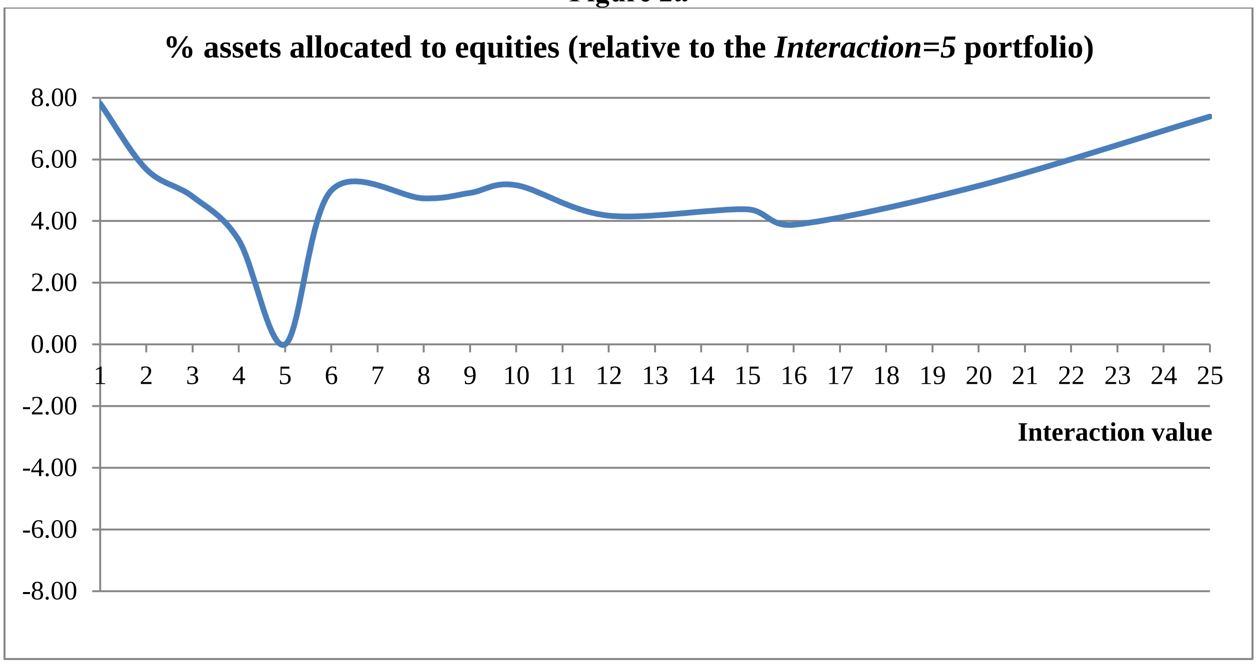

Figure 2b

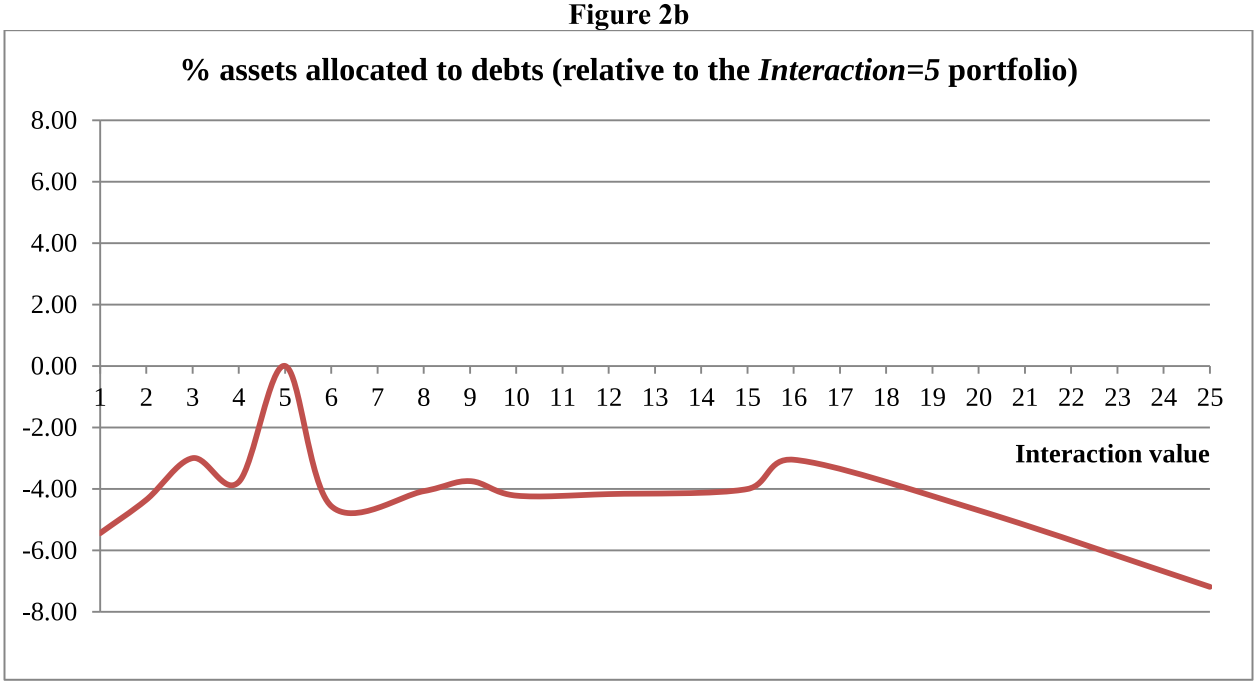

Figure 3: The effect of a risk-adjusted premium scheme on risk shifting in the U.K.

We examine whether risk shifting is subdued in the U.K. after the PPF started charging a risk-adjusted premium in 2006. Figure 3a plots the average percentage of pension assets allocated to equities vs. the joint effect of *Funding level* quintiles and *Survival probability* quintiles during 2003-2005 (*Before*) and 2006-2011 (*After*) respectively. Figure 3b plots the average percentage of pension assets allocated to debts vs. the joint effect of *Funding level* quintiles and *Survival probability* quintiles during 2003-2005 (*Before*) and 2006-2011 (*After*) respectively. The data used in the figures are obtained from the regression results in Table 6. See Appendix A for variable definitions.

Figure 3a

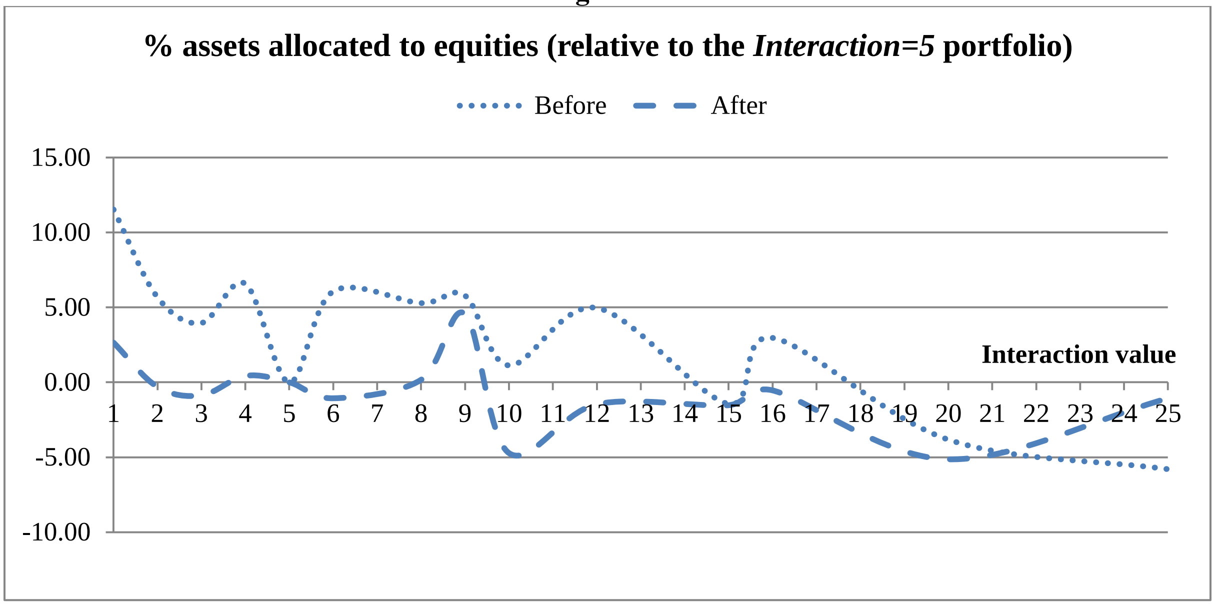

Figure 3b

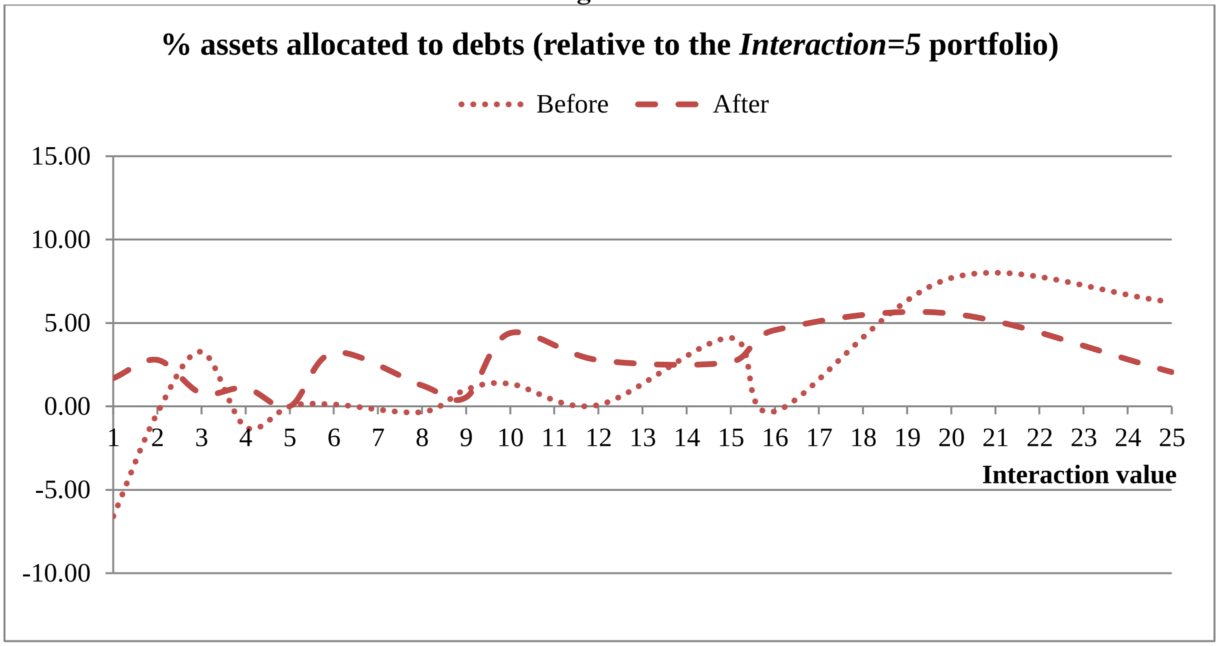

Table 1: Summary statistics

Panel A reports the summary statistics of our main variables. *Funding level, Past investment return, Pension size, Pension life cycle, Effective tax rate, Leverage, and Firm size* are winsorized at the top and bottom 1% level. Panel B reports the mean of four key variables by year. In Panel C, we divide *Funding level* and *Survival probability* into quintiles, construct their interaction values, and report the range of their values in each category. See Appendix A for variable definitions.

Panel A: Descriptive statistics

Variables	Min	P25	Median	P75	Max	Mean	Stdev
% pension assets allocated to equities	0	52.000	61.000	68.000	100	58.034	17.321
% pension assets allocated to debts	0	26.500	33.000	40.950	100	34.872	16.351
Funding level	0.262	0.676	0.788	0.906	1.433	0.796	0.194
Survival probability	0.212	0.997	0.999	>0.999	1.000	0.994	0.030
Past investment return	-0.308	0.046	0.098	0.137	0.300	0.073	0.123
Pension size	0.002	0.021	0.085	0.203	0.963	0.148	0.180
Pension life cycle	0.003	0.033	0.047	0.062	0.184	0.051	0.028
Open/Frozen status	0	0	0	0	1	0.100	0.300
Reporting regime	0	0	1	1	1	0.648	0.478
Effective tax rate	-1.804	0.225	0.314	0.365	1.745	0.258	0.359
Leverage	0.000	0.069	0.174	0.297	0.794	0.204	0.168
Firm size	3.725	6.674	7.824	9.077	13.085	7.918	1.831

Panel B: Mean values of key variables by year

Year	No. of obs.	*% pension assets allocated to equities*	*% pension assets allocated to debts*	*Funding level*	*Survival probability*
2003	794	61.653	31.559	0.806	0.996
2004	1,085	62.859	31.387	0.796	0.998
2005	1,182	62.716	31.409	0.786	0.998
2006	1,188	62.271	31.504	0.854	0.998
2007	1,131	60.077	32.870	0.912	0.996
2008	1,082	52.252	38.797	0.726	0.979
2009	1,034	53.364	38.740	0.753	0.989
2010	1,000	54.308	38.176	0.779	0.996
2011	976	51.704	40.216	0.741	0.996

Panel C: Quintile statistics

Funding level quintile	No. of obs	Min *Funding level*	Max *Funding level*	Min *Survival prob.*	Max *Survival prob.*
1	1,895	0.000	0.651	0.212	>0.999
2	1,894	0.651	0.746	0.217	>0.999
3	1,895	0.746	0.831	0.449	>0.999
4	1,894	0.831	0.936	0.518	>0.999
5	1,894	0.936	2.800	0.758	>0.999

Survival prob quintile	No. of obs	Min *Funding level*	Max *Funding level*	Min *Survival prob.*	Max *Survival prob.*
1	1,896	0.000	2.577	0.212	0.996
2	1,893	0.099	2.460	0.996	0.999
3	1,901	0.000	2.800	0.999	>0.999
4	1,888	0.001	2.549	>0.999	>0.999
5	1,894	0.011	2.748	>0.999	>0.999

Interaction value	No. of obs	Min *Funding level*	Max *Funding level*	Min *Survival prob.*	Max *Survival prob.*
1	529	0.000	0.651	0.212	0.996
2	845	0.099	0.746	0.217	0.999
3	679	0.000	0.831	0.449	>0.999
4	1,032	0.001	0.936	0.518	>0.999
5	589	0.011	2.577	0.758	>0.999
6	799	0.651	0.831	0.996	>0.999
8	684	0.651	0.936	0.996	>0.999
9	375	0.746	0.830	0.999	>0.999
10	635	0.651	2.460	0.996	>0.999
12	773	0.747	0.936	0.999	>0.999
15	795	0.746	2.800	0.999	>0.999
16	414	0.831	0.936	>0.999	>0.999
20	877	0.831	2.549	>0.999	>0.999
25	446	0.937	2.748	>0.999	>0.999

Table 2: Joint effect of funding level and financial health on pension asset allocation

Panel A: Cartesian product table

We sort *Funding level* and *Survival probability* into quintiles separately, and construct 25 dummy variables each representing one of the intersections. We regress *% pension assets allocated to equities (debts)* on these dummy variables (omitting the intersection of the two middle quintiles, i.e., 3×3), control variables, and year fixed effect. We report the coefficients of the remaining dummy variables, which represents the deviation from the coefficient of interaction 3×3. See Appendix A for variable definitions.

% pension assets allocated to equities		*Survival probability* quintile				
		1	2	3	4	5
Funding level quintile	1	2.853	1.133	0.501	-0.226	-4.300
	2	0.327	-0.649	0.754	0.787	0.587
	3	-0.845	-0.595	-	0.185	0.747
	4	-4.310	-1.128	-1.691	-1.036	0.258
	5	-5.399	-0.065	-1.893	0.160	2.424

% pension assets allocated to debts		*Survival probability* quintile				
		1	2	3	4	5
Funding level Quintile	1	-1.653	-0.935	0.621	-1.679	1.950
	2	-0.215	-1.232	-1.420	-0.811	-0.547
	3	0.902	-0.204	-	-0.985	-0.066
	4	3.617	0.136	0.148	0.692	-0.040
	5	5.009	-0.431	-0.504	-2.075	-3.412

Panel B: Parsimonious regression model

We interact quintiles of *Funding level* and *Survival probability* to construct *Interaction* which takes 14 unique values. We use 14 dummy variables each representing a unique *Interaction* value, omitting *Interaction=5*. The dependent variable for Model 1 (2) is the percentage of pension assets allocated to equities (debts). We report regression coefficients followed by heteroscedasticity-consistent standard errors (White, 1980) clustered by firm (Petersen, 2009) in parenthesis. *, **, *** indicate that a coefficient is statistically different from zero at the 0.10, 0.05, and 0.01 level, respectively. See Appendix A for variable definitions.

	(1) *% pension assets allocated to equities*	(2) *% pension assets allocated to debts*
Intercept	53.398***	44.123***
	(2.395)	(2.242)
Interaction=1	7.813***	-5.446***
	(1.662)	(1.572)
Interaction=2	5.680***	-4.359***
	(1.475)	(1.415)

Interaction=3	4.795***	-3.002**
	(1.390)	(1.369)
Interaction=4	3.378***	-3.777***
	(1.272)	(1.249)
Interaction=6	4.991***	-4.565***
	(1.331)	(1.300)
Interaction=8	4.736***	-4.076***
	(1.314)	(1.302)
Interaction=9	4.912***	-3.750***
	(1.434)	(1.422)
Interaction=10	5.162***	-4.222***
	(1.265)	(1.250)
Interaction=12	4.175***	-4.173***
	(1.330)	(1.285)
Interaction=15	4.380***	-4.007***
	(1.309)	(1.283)
Interaction=16	3.880***	-3.054**
	(1.449)	(1.357)
Interaction=20	5.142***	-4.702***
	(1.356)	(1.328)
Interaction=25	7.388***	-7.192***
	(1.452)	(1.432)
Past investment return	16.689***	-11.621***
	(2.226)	(2.232)
Pension size	2.327	-5.201***
	(2.103)	(1.597)
Pension life cycle	-29.046**	14.350
	(11.942)	(11.059)
Open/Frozen status	-1.414	1.198
	(1.277)	(1.204)
Reporting regime	0.016	-0.027
	(1.074)	(1.025)
Effective tax rate	2.116***	-0.621
	(0.598)	(0.520)
Leverage	1.435	-4.370**
	(2.051)	(1.955)
Firm size	0.152	-0.718***
	(0.226)	(0.202)
Year fixed effect	Yes	Yes
No. of obs.	9,472	9,472
Adjusted R^2	0.088	0.071

Table 3: Joint effect of changes in funding level and financial health on active re-allocation of pension assets

We examine the joint effect of changes in *Funding level* and *Survival probability* on active re-allocation of pension assets. The dependent variable for Model 1 (2) is the percentage of pension assets actively re-allocated to equities (debts), the estimation details of which are outlined in Appendix B. We report regression coefficients followed by heteroscedasticity-consistent standard errors (White, 1980) clustered by firm (Petersen, 2009) in parenthesis. *, **, *** indicate that a coefficient is statistically different from zero at the 0.10, 0.05, and 0.01 level, respectively. See Appendix A for variable definitions.

	(1) *% active re-allocation to equities*	(2) *% active re-allocation to debts*
Intercept	-0.795***	0.878***
	(0.119)	(0.114)
Δ*Interaction*	-0.138***	0.196***
	(0.023)	(0.023)
Δ*Pension size*	-13.260***	7.213
	(4.968)	(4.702)
Δ*Pension life cycle*	1.171	1.599
	(6.584)	(6.322)
Δ*Open/Frozen status*	1.305	0.583
	(1.082)	(0.975)
Δ*Reporting regime*	-0.314	-0.060
	(0.275)	(0.268)
Δ*Effective tax rate*	0.043	-0.081
	(0.206)	(0.163)
Δ*Leverage*	2.092	0.154
	(2.024)	(2.087)
Δ*Firm size*	-3.121***	1.750*
	(0.964)	(0.938)
No. of obs.	7,867	7,867
Adjusted R^2	0.009	0.013

Table 4: Risk shifting in financial crisis

We extract a constant sample of 1,033 firms that have available data in both 2007 and 2008. Using only the observations in this constant sample, we sort firms into *Funding level* and *Survival probability* quintiles separately according to their position in 2008 and interact the quintiles to construct *Interaction*. We regress *% active re-allocation to equities* and *% active re-allocation to debts* on changes in *Interaction* and changes in control variables. We report regression coefficients followed by heteroscedasticity-consistent standard errors (White, 1980) clustered by firm (Petersen, 2009) in parenthesis. *, **, *** indicate that a coefficient is statistically different from zero at the 0.10, 0.05, and 0.01 level, respectively. See Appendix A for variable definitions and Appendix B for details on the estimation of *% active re-allocation to equities* and *% active re-allocation to debts*.

	(1) *% active re-allocation to equities*	(2) *% active re-allocation to debts*
Intercept	3.624***	-2.929***
	(0.344)	(0.398)
Δ*Interaction*	-0.236***	0.206***
	(0.052)	(0.062)
Δ*Pension size*	-7.759	-28.508***
	(10.289)	(9.956)
Δ*Pension life cycle*	10.934	3.729
	(13.731)	(17.208)
Δ*Open/Frozen status*	1.463	0.509
	(2.839)	(3.064)
Δ*Effective tax rate*	-0.066	0.334
	(0.620)	(0.672)
Δ*Leverage*	3.294	3.466
	(4.279)	(4.861)
Δ*Firm size*	-2.440	-5.011**
	(2.124)	(2.533)
No. of obs.	1,033	1,033
Adjusted R^2	0.017	0.013

Table 5: Alternative proxy for financial health

We examine if our results are robust to an alternative proxy for financial health. We use the coefficients in Table 4 of Campbell, Hilscher, and Szilagyi (2008), which are estimated based on a modified Shumway's (2001) hazard model, to estimate the probability of default. The dependent variable for Model 1 (2) is the percentage of pension assets allocated to equities (debts). We report regression coefficients followed by heteroscedasticity-consistent standard errors (White, 1980) clustered by firm (Petersen, 2009) in parenthesis. *, **, *** indicate that a coefficient is statistically different from zero at the 0.10, 0.05, and 0.01 level, respectively. See Appendix A for variable definitions.

	(1) *% pension assets allocated to equities*	(2) *% pension assets allocated to debts*
Intercept	54.159***	43.714***
	(2.347)	(2.147)
Interaction=1	6.983***	-5.408***
	(1.734)	(1.611)
Interaction=2	4.982***	-4.134***
	(1.536)	(1.411)
Interaction=3	4.654***	-3.537***
	(1.395)	(1.346)
Interaction=4	2.845**	-3.106**
	(1.352)	(1.337)
Interaction=6	3.802***	-3.700***
	(1.329)	(1.250)
Interaction=8	3.650***	-3.742***
	(1.339)	(1.287)
Interaction=9	5.007***	-4.333***
	(1.485)	(1.372)
Interaction=10	4.636***	-4.770***
	(1.309)	(1.235)
Interaction=12	3.855***	-3.752***
	(1.389)	(1.296)
Interaction=15	4.262***	-4.617***
	(1.369)	(1.271)
Interaction=16	3.151**	-3.083**
	(1.556)	(1.455)
Interaction=20	4.421***	-4.389***
	(1.427)	(1.338)
Interaction=25	5.446***	-6.275***
	(1.683)	(1.551)
Control Variables	Yes	Yes
Year fixed effects	Yes	Yes
No. of obs.	9,439	9,439
Adjusted R^2	0.086	0.071

Table 6: The effect of a risk-adjusted premium scheme on risk shifting in the U.K.

We examine whether risk shifting is subdued in the U.K. after the PPF implemented a scheme of which the pension premium charged is adjusted for sponsor default risk and plan underfunding risk from 2006. The sample period is 2003-2011. The dependent variable for Model 1 (2) is the percentage of pension assets allocated to equities (debts). *After* is an indicator variable, taking the value of one for the subperiod 2006-2011, and zero otherwise. We report regression coefficients followed by heteroscedasticity-consistent standard errors (White, 1980) clustered by firm (Petersen, 2009) in parenthesis. *, **, *** indicate that a coefficient is statistically different from zero at the 0.10, 0.05, and 0.01 level, respectively. See Appendix A for variable definitions.

	(1) *% pension assets allocated to equities*	(2) *% pension assets allocated to debts*
Intercept	64.469***	20.836***
	(7.960)	(6.871)
Interaction=1	11.532**	-6.592
	(4.900)	(4.388)
Interaction=2	5.674	-0.391
	(4.382)	(3.690)
Interaction=3	3.961	3.272
	(4.234)	(3.863)
Interaction=4	6.576*	-1.248
	(3.985)	(3.375)
Interaction=6	6.070	0.116
	(4.081)	(3.625)
Interaction=8	5.286	-0.340
	(4.279)	(3.632)
Interaction=9	5.785	1.010
	(4.286)	(4.062)
Interaction=10	1.125	1.352
	(4.194)	(3.304)
Interaction=12	4.966	0.087
	(3.960)	(3.483)
Interaction=15	-1.440	4.106
	(4.098)	(3.587)
Interaction=16	2.965	-0.296
	(4.056)	(3.690)
Interaction=20	-3.823	7.700*
	(4.449)	(4.009)
Interaction=25	-5.796	6.259
	(5.018)	(4.307)
After	16.071*	-11.008
	(8.235)	(7.037)
Interaction=1 × After	-8.883*	8.280*
	(5.014)	(4.590)
Interaction=2 × After	-5.979	3.177
	(4.539)	(4.100)
Interaction=3 × After	-4.831	-2.491
	(4.238)	(4.178)

Interaction=4 × After	-6.144	2.355
	(4.072)	(3.638)
Interaction=6 × After	-7.133*	3.113
	(4.223)	(4.129)
Interaction=8 × After	-5.114	1.598
	(4.495)	(4.146)
Interaction=9 × After	-1.215	-0.465
	(4.505)	(4.438)
Interaction=10 × After	-5.847	3.045
	(4.607)	(3.912)
Interaction=12 × After	-6.429	2.687
	(4.057)	(3.808)
Interaction=15 × After	-0.088	-1.442
	(4.476)	(4.170)
Interaction=16 × After	-3.504	4.871
	(4.363)	(4.118)
Interaction=20 × After	-1.313	-2.137
	(4.576)	(4.108)
Interaction=25 × After	4.730	-4.200
	(5.274)	(5.218)
Control Variables	Yes	Yes
No. of obs.	2,477	2,477
Adjusted R^2	0.171	0.098

Table 7: Standard terminations and distress terminations through the PBGC

We examine whether pension asset allocation differs between standard termination firms and distress termination firms. DB plan termination data are provided by the PBGC. Panel A presents the number of public firms which terminated DB plans through standard termination and distress termination respectively. Panel B compares the pension asset allocations between these two types of terminations in the last three years before the plan terminations. Panel C compares the pension asset allocations of distress termination firms and a set of matched non-distressed firms. We match by year, two-digit SIC code, and firm size.

Panel A: DB plan terminations by public firms

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**Total**
Standard Terminations	10	12	4	19	9	7	-	16	14	91
Distress Terminations	17	7	16	4	1	4	17	5	3	74
Total	27	19	20	23	10	11	17	21	17	165

Panel B: Asset allocations before DB plan terminations: standard terminations versus distress terminations

	Year t-1 before termination			**Year t-2 before termination**			**Year t-3 before termination**		
	Distress terminations	Standard terminations	t-value (p-value)	Distress terminations	Standard terminations	t-value (p-value)	Distress terminations	Standard terminations	t-value (p-value)
Firms that terminated some of or all their DB plans:									
% Equities	62.20	53.25	**2.19 (0.03)**	65.65	53.25	**1.85 (0.07)**	55.58	53.25	0.87 (0.39)
% Debts	34.33	43.93	**-2.27 (0.03)**	31.71	43.93	**-1.84 (0.07)**	38.64	43.93	-1.16 (0.25)
Firms that terminated all their DB plans:									
% Equities	62.68	48.00	**2.34 (0.03)**	65.95	52.13	**1.71 (0.10)**	54.87	53.07	0.21 (0.84)
% Debts	35.13	49.71	**-2.18 (0.04)**	32.72	46.49	-1.68 (0.11)	40.53	46.09	-0.61 (0.54)

Panel C: Asset allocations before DB plan terminations: distress termination firms versus matched non-distressed firms

	Year t-1 before termination			**Year t-2 before termination**			**Year t-3 before termination**		
	Distress terminations	Matched firms	t-value (p-value)	Distress terminations	Matched firms	t-value (p-value)	Distress terminations	Matched firms	t-value (p-value)
Firms that terminated some of or all their DB plans:									
% Equities	62.20	50.25	**1.97 (0.06)**	65.65	60.89	0.74 (0.46)	55.58	55.92	-0.05 (0.96)
% Debts	34.33	43.95	**-1.83 (0.08)**	31.71	31.40	0.05 (0.96)	38.64	37.86	0.10 (0.92)
Firms that terminated all their DB plans:									
% Equities	62.68	49.24	**2.34 (0.03)**	65.95	60.81	0.70 (0.49)	54.87	55.23	-0.04 (0.97)
% Debts	35.13	44.83	**-2.18 (0.04)**	32.72	30.99	0.23 (0.82)	40.53	38.16	0.28 (0.78)

Table 8: PBGC cases

Case 1: Delphi Automotive PLC.

Delphi Automotive PLC, spun off from the General Motors Corporation (GM) in 1999, was one of the world's largest automotive parts manufacturers. In 2004, Delphi was investigated by the Securities and Exchange Commission for fraudulent accounting practices and financial transactions. In October 2005, Delphi filed for Chapter 11 bankruptcy protection. In October 2009, with the sale of its assets to its lenders and GM, Delphi finally exited bankruptcy.

Delphi sponsored two DB plans - Delphi salaried employees plan, and Delphi hourly employees plan. Delphi did not make any contributions to the plans for four consecutive years before they were taken over by the PBGC in July 2009. On PBGC termination the two plans were only 52% and 49% funded respectively according to the PBGC. The funding shortfall amounted to about $6.2 billion in pension liabilities, the second largest in the PBGC's history.

We report the percentages of pension assets allocated to equities (debts) for Delphi during 2002-2008. We also report the mean percentage of pension assets allocated to equities (debts) by the industry peers in each year. The industry peers are defined using the 2-digit SIC code. We note that Delphi had invested its pension assets more conservatively relative to its peers before 2005. Nevertheless, Delphi became more aggressive in the last four years before its bankruptcy, taking on more risk than its industry peers. More interestingly, although the whole stock market plummeted in 2008 due to the financial crisis, the percentage of pension assets allocated to equities remained unchanged at Delphi in 2008, suggesting that the firm had shifted more pension assets to risky equities before the PBGC takeover.

	2002	2003	2004	2005	2006	2007	2008
Percentage of pension assets allocated to equities							
Delphi	60%	59%	61%	67%	64%	63%	63%
Industry peers (mean)	70%	62%	61%	63%	62%	60%	53%
Difference	**-10%**	**-3%**	**0**	**4%**	**2%**	**3%**	**10%**
Percentage of pension assets allocated to debts							
Delphi	31%	30%	32%	26%	25%	25%	20%
Industry peers (mean)	24%	32%	32%	32%	33%	34%	41%
Difference	**7%**	**-2%**	**0**	**-6%**	**-8%**	**-9%**	**-21%**

Case 2: Milacron Inc.

Incorporated in 1885, Milacron Inc. was a leading plastics processing and industrial fluids company. By the middle of the 20th century Milacron had grown to be the world's largest manufacturer of machine tools. During the 2007-2008 financial crisis, the deterioration in global economic conditions resulted in a dramatic decline in sales and orders for Milacron's products. The company was also hurt by high oil and resin prices - key ingredients for plastics making. Milacron reported a net loss of $25 million in 2008. In March 2009, Milacron announced its filing for Chapter 11 bankruptcy. In August 2009, Milacron exited bankruptcy protection with a new group of investors that includes Avenue Capital Group and DDJ Capital Management.

Milacron sponsored one principal DB plan, covering about 8,400 participants. The plan was frozen on December 31, 2007 and then taken over by the PBGC in June 2009. On termination, the Milacron plan was about 50% funded, with assets of $272 million and liabilities of $544 million, according to the PBGC.

We report similar pension asset allocation data in the table below - for Milacron and for its industry peers during 2003-2007. The table shows that the percentage allocated to risky equities increased from 65% in 2003 to 74% in 2007 at Milacron. Overall, Milacron had held a more equity-heavy pension portfolio compared with its industry peers. The deviation from its peers manifested itself in the last three years before the plan termination. The percentage of pension assets allocated to equities for Milacron were 71%, 74%, and 74% respectively, while the peers reported a mean of 61%, 62%, and 57% only.

	2003	2004	2005	2006	2007
Percentage of pension assets allocated to equities					
Milacron	65%	69%	71%	74%	74%
Industry peers (mean)	61%	61%	61%	62%	57%
Difference	**4%**	**8%**	**10%**	**12%**	**17%**
Percentage of pension assets allocated to debts					
Milacron	34%	31%	29%	26%	22%
Industry peers (mean)	31%	32%	32%	30%	33%
Difference	**3%**	**-1%**	**-3%**	**-4%**	**-11%**

Case 3: United Airlines Inc. (UAL)

United Airline was once the largest air carrier in the western world, with a history dating back to the 1930s. During the September 11, 2001 terrorist attacks, two UAL airplanes were hijacked and crashed. An airline industry downturn resulted, coupled with skyrocketing oil prices, and high labor costs. UAL reported a record loss of $2.1 billion in 2001. In December, 2002, UAL filed for Chapter 11 reorganization. In 2006, UAL exited bankruptcy after a period of major restructuring, including employee layoffs and flight routes reduction. In 2010 UAL merged with Continental Airlines.

Back to June 2005, the court approved the UAL management's request to terminate four pension plans sponsored by UAL: for ground employees, pilots, management, and flight attendants. According to the PBGC, the four plans were all less than 50% funded on their terminations. The funding shortfall, estimated to be around $8.3 billion, was the largest in the PBGC's history. The highest paid UAL workers, such as pilots, faced pension cut of up to 50% after the PBGC takeover.

We report similar pension asset allocation data in the table below - for UAL and for its industry peers. Since the UAL plans were terminated in June 2005 and disclosure of pension allocation was not required before 2003, we obtain the allocation data for three years only: 2002-2004. UAL's allocation of pension assets to equities increased from 58% to 63% in two years' time. Given the mega size of the plans, an increase of five percent to risky equities can have a huge impact. We acknowledge that the limited data make it difficult to draw a solid conclusion on any potential risk shifting in this case.

	2002	2003	2004
Percentage of pension assets allocated to equities			
United Airlines	58%	60%	63%
Industry peers (mean)	59%	58%	61%
Difference	**-1%**	**2%**	**2%**
Percentage of pension assets allocated to debts			
United Airlines	37%	35%	32%
Industry peers (mean)	41%	35%	35%
Difference	**-4%**	**0**	**-3%**