Corporate Pension Risk Transfers*

Sven Klingler   Suresh Sundaresan   Michael Moran

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Abstract

Between 2012 and 2020, corporate sponsors of defined benefit (DB) pension plans transferred around $100 billion pension obligations for more than one million plan participants to insurance companies using *pension risk transfers* (PRTs). We model the decision to conduct such transfers as real-option exercise problem and assemble a new PRT database to test our theory. Consistent with our model, the propensity to conduct a PRT is higher for firms with higher pension-related costs, lower stock market investments, and lower default risk. Hence, PRTs are more common among safer sponsors and potentially lower the aggregate quality of the remaining sponsor pool.

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*Klingler is with the Department of Finance, BI Norwegian Business School, Nydalsveien 37, NO-0442 Oslo, Norway. E-mail: sven.klingler@bi.no. Sundaresan is with Columbia Business School, 3022 Broadway, Uris Hall 401 New York, NY 10027. E-mail: ms122@gsb.columbia.edu. Moran is with Goldman Sachs Asset Management. We are grateful to seminar participants at BI Oslo and to Bruno Gerard for helpful comments. We are also grateful to Moody's Analytics for providing us with EDF data for the firms in our study.

Introduction

Companies in charge of sponsoring defined benefit (DB) pension plans face macroeconomic risks, such as falling interest rates and aggregate stock market declines. These risks can deteriorate a plan's funding status (i.e., the difference between pension liabilities and pension assets) and increase the pension-related costs for the sponsor. The sheer size of many DB pension plans—in some cases, the pension obligations even exceed the sponsor's market capitalization—can make these pension-related costs and risks first-order concerns, potentially affecting the sponsor's credit quality and equity valuation. While companies have been reducing such concerns by transitioning from DB to defined contribution (DC) plans, this transition does not address the risk exposure from legacy DB plans. One strategy to reduce this risk exposure are *pension risk transfers* (PRTs), transactions that involve purchasing annuities from a life insurance company to irrevocably transfer the pension liabilities to the insurer. These PRTs increased substantially in popularity since 2012 and are the focus of our paper.

We model the decision to conduct such transfers as a real-option exercise problem and assemble a new data set of PRTs that allows us to test our theory. Based on our new data, we estimate that, during the 2012 to 2020 period, corporate sponsors of defined benefit (DB) pension plans in the U.S. used PRTs to transfer around $100 billion pension obligations for more than one million plan participants to insurance companies. In line with our model, we find that the propensity to conduct a PRT is higher for firms with higher pension-related costs, lower stock market investments, and lower default risk. Hence, PRTs are more common among safer sponsors and potentially lower the aggregate quality of the remaining sponsor pool as riskier plan sponsors are less likely to conduct a PRT.

One company vividly illustrating the macroeconomic risks and costs associated with sponsoring a DB plan is General Motors. The company had fully funded DB pension plans in 2006 but accumulated a pension funding deficit worth more than 20% of the total firm assets by 2009. In 2012, the company responded to these challenges by purchasing annuities from the Prudential Insurance Company of America for the benefit of irrevocably transferring a portion of its pension obligations to the insurer. Together with another huge PRT conducted by Verizon in the same year, this transaction started a new trend. In our sample alone, we observe 149 PRTs during the 2012 to 2020 period, which reduced the pension obligations and number of plan participants in our sample by approximately 4% and 7%, respectively. While these numbers are still relatively small, a survey of major corporate plan sponsors suggests that the majority of corporate DB sponsors in the U.S. expects to "completely offload their pension liabilities in the foreseeable future" (MetLife, 2021).

To better understand the drivers behind PRTs, we set up a model in which the sponsor weighs the cost of transferring the plan to a third party against reducing future pension risks and expenses. The costs associated with exercising this real option are that the sponsor must fully fund the transferred liabilities and loses what we call the "option value of waiting." This option value arises because future increases in the value of pension plan assets could lower the funding cost associated with the transfer. Two testable predictions from our model are that sponsors with (i) higher macroeconomic risk exposure and (ii) less volatile pension plan assets are more likely to conduct a PRT. Moreover, because sponsors value a reduction in their future pension-related costs more when they are further away from default (because the expected time horizon for future cost saving is longer), safer companies are more likely to conduct a PRT.

In our model, we take the fraction of pension obligations that can be transferred as exogenously given. In practice, this fraction depends on the annuity pricing from the life insurer, which varies across participants—annuities for retired employees tend to be better priced as the insurance company faces less uncertainty regarding their future pensions. Moreover, an additional factor when considering a PRT is the pension insurance provided by the Pension Benefit Guaranty Corporation (PBGC). In return for regular insurance payments, the pension sponsor has access to the PBGC put option (e.g., Sharpe, 1976, Treynor, 1977, Pennacchi and Lewis, 1994, van Binsbergen, Novy-Marx, and Rauh, 2014, among others) and while conducting a PRT reduces future PBGC premiums, it also lowers the value of the PBGC put option. Because part of the PBGC premium depends only on the number of plan participants (independent of the pension obligations associated with them), firms with more inactive employees face higher PBGC premiums relative to the value of their PBGC put option. Hence, the structure of the PBGC premiums together with the cheaper annuity pricing for retired participants imply that companies with more inactive employees are more likely to conduct a PRT.

Empirically, we focus on corporate sponsors of DB pension plans headquartered in the U.S. and assemble a comprehensive hand-collected sample of PRTs, combining reports by PIonline, a proprietary sample of PRTs collected by Goldman Sachs, and information from company's annual reports. Using this sample, we compare firms (or firm-years) with PRTs to other firms (or firm years) without a PRT.

To test our prediction that macroeconomic risks and associated costs with sponsoring a DB pension plan are a key driver behind the choice to conduct a PRT, we construct a new measure of realized macroeconomic pension risks for each sponsor in our sample. Our measure is the standard deviation of the difference between pension assets and pension liabilities, *divided by the sponsoring firm's assets,* and captures fluctuations in a plan's funded status during the 2000 to 2009 period. During this period, macroeconomic risks manifested as the U.S. economy went through two recessions and pension sponsors faced steep stock market declines and large swings in interest rates. In addition, focusing on information from several years before the start date of our PRT sample is better than using contemporaneous measures of pension-related costs as pension-related costs can increase *because* a company plans a PRT.

Linking our risk measure to PRTs, Figure 1 shows a binned scatter plot with the propensity that a firm conducts at least one PRT during the 2012 to 2020 period on the y-axis against our risk measure on the x-axis. We indicate the total number of PRTs (some companies can conduct multiple PRTs during our sample period) by the size of the blue circles. As we can see from the figure, the propensity to conduct a PRT increases with higher macroeconomic risk exposure during the 2000 to 2009 period.

While Figure 1 provides the first evidence that macroeconomic cost savings are an important driver of PRTs, we next test our theory more formally using logistic regressions. We start by running cross-sectional regressions in which the dependent variable equals one for companies that conduct at least one PRT during the 2012 to 2020 period and zero otherwise. This analysis confirms that prior fluctuations in underfunding relative to the firm's assets are a significant driver of the propensity to conduct a risk transfer—a 1% increase in the macro-economic risk exposure increases the propensity to conduct a PRT by 25%. In addition, supporting our other hypotheses, firms with lower equity allocations, more inactive employees, and less default risk are more likely to conduct a PRT.

Taking the time series dimension of our data into account, we show that sponsors conducting a PRT in the following year have significantly lower equity allocations, default probabilities, and underfunding in their plans compared to similar sponsors that do not conduct a PRT. We confirm the robustness of these results in panel regressions, where we use infor-

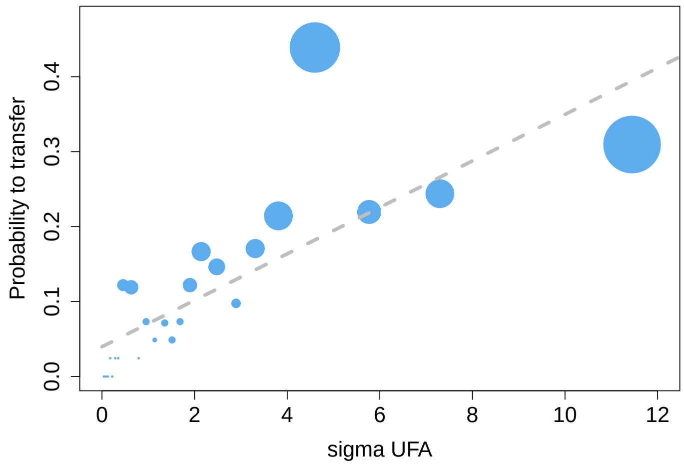

Figure 1: **Pension risk transfers and underfunding risk.** This figure shows a binned scatter plot with 25 bins, which are based on $\sigma(UFA)$, which captures the standard deviation of each plan sponsors' underfunded status relative to firm assets during the 2000 to 2009 period. The y-axis shows the propensity that a sponsor in a given bin conducts at least one PRT during the 2012 to 2020 period. The size of the circles indicates the total number of PRTs conducted in each underfunding risk bin.

mation from year t to predict the propensity of conducting a PRT in year $t+1$ and add a battery of control variables.

We conclude by highlighting three consequences of PRTs from the perspective of the PBGC. First, PRTs reduce the number of plan participants covered by the PBGC and thus erode the premium base of plans and employees. While we estimate the reduction in PBOs due to PRTs around 4%, the number of plan participants decreases by more than 7%. Second, PRTs alter the pool of PBGC insured participants toward active participants, who can continue accumulating pension benefits and are therefore more risky to insure than inactive participants. Specifically, we estimate that PRTs decreased the fraction of inactive employees insured by the PBGC by approximately 3%. Finally, while PRTs have a minor effect of 0.5% on the aggregate equity allocation in the pool of PBGC insured companies, the aggregate underfunding in the PBGC is approximately 4% higher than it would be if none of the sponsors transferred any PBOs. Hence, PRTs tend to increase the pool risk of the pension plans in our sample.

Our study contributes to a large literature examining the risks of corporate DB pension plans and firms' responses to these risks. Sponsoring a DB pension plan can affect a firm's investments and capital structure (Rauh, 2006, Franzoni, 2009, Campbell, Dhaliwal, and Schwartz Jr, 2012, Bartram, 2017), financing decisions (Shivdasani and Stefanescu, 2010), stock price (Jin, Merton, and Bodie, 2006, Franzoni and Marin, 2006, Rauh, 2009, Axenrod and Kisser, 2021), and even trigger earnings manipulations (Bergstresser, Desai, and Rauh, 2006). We contribute to this literature by providing a theoretical framework for how companies value the option to transfer their pension liabilities and by providing empirical evidence on the factors driving the PRT decision. While companies have been mitigating their DB plan exposures by freezing their pension plans for years (Stock and Wise, 1990, Munnell, Golub-Sass, Soto, and Vitagliano, 2006, Munnell and Soto, 2007, Rauh and Stefanescu, 2009, Rauh, Stefanescu, and Zeldes, 2020), PRTs of sizeable magnitude are a more recent phenomenon with different economic drivers. To illustrate this point, note that Rauh et al. (2020) find that companies are more likely to freeze plans with more active employees (to avoid accruing further PBOs) while companies are more likely to transfer plans with a lower fraction of active employees.

While PRTs are still increasing in popularity among corporate sponsors and already affected more than one million plan participants, these transactions have received little attention in the academic literature. One exception are Cantor, Hood, and Power (2018), who use some of the major PRT announcements to study the immediate equity and debt market reactions for the sponsoring firm. To the best of our knowledge, our work is the first study that provides a theoretical framework for how companies evaluate the option to transfer their pension liabilities. In addition, our empirical study is the first to assemble a comprehensive set of PRTs and study the decision to transfer pension liabilities empirically.

1 Institutional Background

Sponsors of defined benefit (DB) pension plans face macroeconomic risks unrelated to their main business because falling interest rates increase the present value of their pension liabilities and major stock market downturns can lower the value of their pension assets. These macroeconomic risks materialized during the bust of the dot-com bubble and the global financial crisis of 2007 to 2009, deteriorating the funding status of many plans as the gap between their pension liabilities and pension assets widened. Under the Financial Accounting Standards that came into effect in 2006, also known as FAS 158, sponsors of underfunded pension plans (whose pension liabilities exceed the pension assets) must report the funding deficit as liability in their financial statements (see FASB, 2006 for more details). Moreover, the pension protection act of 2006 can trigger mandatory cash contributions for sponsors of underfunded pension plans. Hence, these macroeconomic risks can result in flow-through costs from pension plans to the sponsoring firms' balance sheets and add earnings volatility unrelated to the core business of the firm.

These pension risks can be first-order concerns for the sponsoring firms as the size of a pension plan sometimes exceeds the sponsor's market capitalization—for instance, General Motor's pension liabilities were 4 times their equity market capitalization in 2011. Given FAS 158 made pension deficits more prominent on the balance sheet, pension risks can directly affect a company's credit quality and equity valuation because funding deficits in the pension plan are an additional liability for the sponsor. To reduce these risks, companies have engaged in different types of *pension de-risking* strategies, which include shifting their investments from stocks to bonds, closing existing DB plans for new employees, transitioning to defined contribution (DC) plans, and stopping the accumulation of new pension liabilities (also known as pension freezes).

While these de-risking strategies stop the accumulation of new pension obligations, they do not reduce the existing and future costs arising from legacy DB plans. In this context, another important cost associated with running a DB plan is the insurance premium paid to the Pension Benefit Guaranty Corporation (PBGC), who guarantees to honor the participants' pension claims (up to a certain threshold) if the sponsor defaults. The PBGC premiums comprise a flat-rate premium that depends on the number of plan participants and a variable-rate premium that is higher for plans with larger funding deficits. In 2012, U.S. Congress passed an Act known as MAP-21 (Moving Ahead for Progress) and, as part of this act, gradually increased both the flat-rate and variable-rate premiums, which more doubled during the 2012 to 2020 period.[1] In addition, MAP-21 introduced a per-participant cap on the variable-rate premium and thereby linked the potential costs of a large funding deficit to the number of plan participants. Traditionally, the cost of paying PBGC insurance premiums is balanced against access to "the PBGC put", which allows a defaulting company to put its unfunded pension liabilities with the PBGC (e.g., Sharpe, 1976, Treynor, 1977, Pennacchi and Lewis, 1994, van Binsbergen et al., 2014, among many others). However, the substantial premium hikes after the enactment of MAP-21 make it plausible that the costs of paying PBGC premiums outweigh the benefits for some sponsors.

[1] The flat premium increased from \$35 per participant in 2012 to \$83 in 2020 and the variable rate premium increased even more substantially from \$9 per $\$1,000$ of unfunded vested benefits (UVBs) in 2012 to \$45 in 2020.

Pension Risk Transfers

To reduce the size of an existing DB plan, a plan sponsor can purchase annuities from a life insurance company and irrevocably transfer its pension obligations to the insurer. This transaction is called a pension risk transfer (PRT) and immediately reduces the costs and risks outlined above. Pension obligations transferred to insurance companies move out of the PBGC system and the participants lose the PBGC protection in exchange for state insurance coverage. We discuss the implications of PRTs for plan participants and other stakeholders in Section 5 and focus our discussion in this section on the costs and benefits of conducting a PRT from the perspective of the corporate sponsor.

When conducting a PRT, the sponsor usually focuses on a subset of participants instead of transferring the entire plan (which would be subject to additional costs) and first needs to gather all relevant information on the affected participants, such as age, address, and payment details. This data gathering process is time consuming and during the process, the sponsor solicits bids from different insurance companies and the decision making usually involves the senior management of the sponsoring firm. Overall, the process can take between 6 and 12 months for medium-sized transfers and potentially longer for larger deals. The decision to transfer a given plan participant can depend on data availability but is largely driven by the annuity pricing from the insurance company, which tends to be more favorable for retired employees, whose pension payments are largely deterministic.

While PRTs have a long tradition—MetLife claims that it conducted the first PRT in history in 1921 (see MetLife, 2021)—the trend to transfer a substantial portion of a firm's pension obligations to an insurance company only accelerated in 2012 after General Motors and Verizon conducted huge PRTs. After these two highly visible transfers, which both transferred the pension liabilities to the Prudential Insurance Company of America, interest in PRTs increased among both corporate DB sponsors and life insurance companies. Illustrating this point, in our sample, the annual number of conducted PRTs increased monotonically until it reached a peak of 30 transfers in 2018, followed by 27 and 23 transfers in 2019 and 2020. Moreover, we observe more than 10 life insurers as counterparties in our PRT sample (see Table A7 in the appendix) and note that, according to Milliman (2021), the average costs for transferring pension obligations, measured as percentage of accounting liabilities, decreased substantially since 2012.[2] According to a recent survey of 253 plan sponsors by MetLife (2021), this trend is expected to accelerate even further as more than 90% of the interviewees "expected to completely offload their pension liabilities in the foreseeable future."

2 Theory and Hypotheses

We now examine the choice to conduct a PRT from the perspective of a corporate sponsor. We first explain that this choice can be cast as a real option exercise problem and examine the costs and benefits of conducting a PRT in a model-free setting. Afterwards, we incorporate these considerations in a simple model and use this framework to derive testable predictions for the propensity to conduct a PRT.

2.1 The Costs and Benefits of Conducting a PRT

To illustrate the economics of PRTs, we focus on a corporate sponsor of an *underfunded* pension plan and sketch out a stylized economic balance sheet, which combines the assets

[2]PRTs are sometimes called "pension buy-outs" and an alternative to this transaction is a "pension buy-in" where a plan sponsor purchases annuities from an insurance company without legally transferring the obligations to the insurer. These transactions are more common outside the U.S. and we therefore focus on PRTs, which are dominant in the U.S.

and liabilities of both the main business and the pension plan. Table 1 shows this balance sheet, where the sponsoring firm has assets V, which are financed with equity E and debt D. As discussed in Section 1, the underfunded plan assets, measured as difference between the present values of pension liabilities L and pension assets A, are an additional liability while neither A nor L appear directly on the sponsoring firm's balance sheet. The focus of our analysis is on the sponsor's decision to conduct a PRT. We view this decision as exercising a real option F, which is an asset on the sponsor's stylized balance sheet. To keep our analysis tractable, we focus on the sponsor's decision to conduct the transfer, assuming that the size of the PRT is exogenously given. This assumption can be motivated by the fact that only a subgroup of the plan participants is eligible for a transfer at a given time, for instance, due to data availability or constraints imposed by the insurer.

Table 1: **Stylized economic balance sheet of a corporate pension plan sponsor.** This table gives a stylized view on the balance sheet of a corporate pension plan sponsor, where V is the value of all firm assets, E and D are the present values of the firm's debt and equity, and $L - A$ are the unfunded pension assets, which are a liability on the sponsor's balance sheet. The other items are specific to the costs and benefits of conducting a pension risk transfer. F is the present value of the real option of conducting a pension risk transfer and P is the value of the PBGC put option. Z and X are the present values of the pension-related macroeconomic costs and the costs associated with PBGC premiums, respectively.

Assets		Liabilities	
V	Firm Assets	E	Equity
		D	Debt
		$L - A$	Unfunded pension assets
F	**Option to transfer the pension plan**	Z	PV of pension-related macroeconomic costs
P	PBGC put option	X	PV of PBGC premium

In this setting, the decision to exercise the option F and conduct a PRT depends on the following four factors. First, when conducting the PRT, the sponsor faces a cost proportional to $L - A$. This cost arises because the sponsor can only transfer fully funded pension obligations and typically wants to avoid conflicts with the remaining participants, which would face a plan with a lower funding status if the sponsor did not make a contribution proportional to $L - A$. Second, exercising the option means that the sponsor loses the "option value of waiting," which arises because the funding status of the plan can improve over time and thereby lower the necessary contribution. Third, conducting the PRT reduces the macroeconomic risks and costs that we discussed in Section 1 and which are represented in the sponsor's economic balance sheet as the liability Z, reflecting the present value of future costs. Finally, because transferred pension liabilities leave the PBGC system, the decision to conduct a PRT lowers the value of the PBGC put option P, which is an asset on the economic balance sheet, and reduces the liability X, which reflects the present value of future PBGC premium payments. In theory, the present value of the PBGC premium offsets the value of the PBGC put and therefore these two items only affect the PRT decision if the sponsor perceives a wedge between them.

In summary, when deciding to conduct a PRT, the sponsor weighs the costs of making a contribution proportional to $L - A$, losing the option value of waiting, and losing the PBGC put option, against the benefits of reducing the macroeconomic risks, pension-related costs, and PBGC premium payments.

2.2 The Model

We now examine the decision to conduct a PRT by incorporating these costs and benefits into a simple continuous-time model with an infinite horizon.

Model Setup

Building on the intuition from Section 2.1, we assume that the pension sponsor contemplates transferring a fixed amount of pension liabilities with present value L. To ease notations, we ignore any additional pension items that are unaffected by the transfer and let $Z = z/r$ and $X = x/r$ denote the present values of the pension-related costs and PBGC premiums that the sponsor saves by conducting the PRT.[3] Further simplifying the model set-up, we assume that the pension assets A_t that would be transferred, are a fraction of the total pension assets, proportional to the fraction of transferred liabilities L. As before, this assumption can be justified by the fact that a PRT should not affect the remaining plan participants. Based on this assumption, conducting the PRT requires the sponsor to make a contribution equal to $L - A$ to the plan.

The dynamics of A_t follow a geometric Brownian motion under the risk-neutral distribution with dynamics

$$dA_t = (r - \delta)A_t dt + \sigma A_t dW_t^A, \tag{1}$$

where δ can be thought of as a flow rate of expenses. Instead of explicitly modeling the investments in stocks and bonds, we argue that the parameter σ captures the plan's stock holdings and we take this parameter as exogenously given. Next, we take the firm's financing choices as exogenously given and assume that the firm value V_t under the risk-neutral distribution follows a geometric Brownian motion

$$dV_t = V_t(r - \lambda)dt + V_t \sigma_V dW_t^V, \tag{2}$$

[3] In our model, we simply assume that these costs are constant and ignore variable-rate premiums, which depend on the funding status of the plan.

where λ can be thought of as a continuous dividend payment. We assume that the firm defaults at the first time V drops below an exogenously given V_B, denote the default time by $\nu \equiv \text{argmin}\{t : V_t \leq V_B\}$, and assume that the equity value of the firm drops to zero in case of default. Finally, we denote the value of the PBGC put option by $P(V, L)$ and summarize all variable specifications in Table A1 in the appendix.

The sponsor maximizes the company's equity value E by trading off the costs and benefits of conducting a PRT and choosing A_U, the value of pension assets at which it is first optimal to conduct the transfer. We use A_U to define $\tau \equiv \text{argmin}\{t : A_t \geq A_U\}$ as the first time when such a transfer is optimal. Considering the mandatory contribution associated with conducting the PRT and the equity-maximizing choice of conducting a PRT, the value of the real option F is then given as:

$$F(A, L) = \max_{A_u} \left\{ E(V, A; A_U, V_B) - (L - A_U)\mathbb{E}^Q[e^{-r\tau}\mathbb{1}_{\{\tau \leq \nu\}}] \right\}, \tag{3}$$

where the value of the sponsoring firm's equity $E(V, A; A_U, V_B)$ can be written as

$$E(V, A; A_U, V_B) = V - D - \int_0^{\min(\tau,\nu)} ze^{-rt}dt - \left(\int_0^{\min(\tau,\nu)} xe^{-rt}dt - P(V, L) \right). \tag{4}$$

To understand Equation 4, we start with the standard definition of a firm's equity value as the difference between the total asset value V and the value of outstanding debt D. From that expression, we subtract the present value of the pension-related costs $\int_0^{\min(\tau,\nu)} ze^{-rt}dt$, which are paid until the firm either conducts a PRT at time τ or defaults at time ν. Finally, we also subtract the last term in Equation (4), which reflects the difference between the present value of future PBGC insurance premiums $\int_0^{\min(\tau,\nu)} xe^{-rt}dt$ and the value of the PBGC put option $P(V, L)$. If this term is positive, the equity holders' cost of paying the

PBGC premium exceeds their valuation of the PBGC put.

No Default Risk

To obtain closed-form solutions, we first focus on the special case with $\nu = \infty$, where ignore the potential default risk of the sponsor. In this case, we assume that the firm does not pay a PBGC premium and has no PBGC put option. Under these assumptions, the following proposition characterizes the propensity to conduct a PRT.

Proposition 1. *Without firm default, the propensity to conduct a PRT is given as:*

$$q(A) = \mathrm{E}^Q\left[e^{-r\tau}\right] = \left(\frac{A}{A_U}\right)^\beta = \left(\frac{\beta-1}{\beta}\frac{A}{L-Z}\right)^\beta, \tag{5}$$

with $A_U = \frac{\beta}{\beta-1}(L-Z)$ *and* $\beta = \frac{-(r-\delta-\frac{\sigma^2}{2})+\sqrt{(r-\delta-\frac{\sigma^2}{2})^2+2r\sigma^2}}{\sigma^2}$.

We relegate the proof of Proposition 1 to the appendix and focus on the economic implications of the proposition instead. As shown in the proposition, $A_U > L - Z$ and therefore the firm does not immediately exercise the PRT option when the pension-related costs (Z) are above the cost of conducting the transfer ($L - A$). Hence, given the optimal asset value for conducting the PRT (A_U), Proposition 1 illustrates the "option value of waiting." In addition, Proposition 1 allows us to derive the following two testable predictions about the propensity to conduct a PRT.

Proposition 2 (Testable Predictions)**.** *The propensity to conduct a PRT*

(a) increases in Z

(b) decreases in σ

As before, we relegate the proof of this result to the appendix and focus on the economic implications instead. Part (a) shows that firms facing higher macroeconomic costs associated with sponsoring their pension plans are more likely to conduct a PRT. Part (b) links the propensity to conduct a PRT to the riskiness of the plan assets. Intuitively, the propensity of a PRT decreases in σ as the option value of waiting is higher for riskier plans. Because plans with a higher σ can be thought of as investing more in stocks, part (b) suggests that plans with more stock holdings are less likely to conduct a PRT.[4] This result fits in the broader picture of pension de-risking strategies because companies that conduct a PRT are actively de-risking and therefore also more likely to hold less risky pension assets.

Numerical Illustrations

We now use numerical approximations for the general case with default risk to illustrate how the propensity to conduct a PRT depends on the main model parameters. We focus on the situation where the PBGC put is fairly priced and assume no correlation between the firm assets and pension assets. Additional discussions of potential PBGC mispricings and the role of correlation between firm assets and pension assets can be found in Appendix B.

We choose the following baseline values for our parameters, which we also summarize in Table A2 in the appendix. We assume a risk-free rate equal to 3% and set δ and λ equal to 1%. Assuming a stock market volatility of 17.5% (which is close to the sample median of 17.32%, based on estimates from Moody's analytics), we set $\sigma_V = 0.175$ and assuming that the plan follows the 60-40 rule, we set the volatility of plan assets to $\sigma = 0.6 \times \sigma_V = 0.105$. We normalize both V and A to have a starting value of 100, set the barrier for firm default

[4]As we explain in the appendix, the correlation between firm value and pension assets can also reflect equity investments and firms with a higher correlation between firm value and plan assets are also less likely to conduct a PRT.

to $V_B = 23$ (which gives a default probability of 15.6% and a distance of default equal to 77%) and set $L = 120$, which calibrates the funding status of the plan to the sample median. Finally, we set $Z = 92$, which corresponds to a constant flow cost of $Z/L \times r = 2.3\%$, and assume no correlation between V and A. We next illustrate how varying each of the key parameters affects the sponsor's propensity to conduct a PRT.

The blue lines in Figure 2 show the propensity to transfer for the case with no default risk and the black lines show the numerical solutions for the case with default risk. The figure is truncated at 0.76, which corresponds to the situation in which A_U exceeds L. The first panel illustrates how increases in the flow-through cost Z affect the optimal transfer. As we can see from the figure, the decision to conduct a transfer is highly sensitive to fluctuations in Z and a small increase of approximately 0.1% increases the propensity to conduct a PRT by approximately 15%. The second panel illustrates how the fraction of plan assets invested in stocks (measured by varying the parameter σ) affects the PRT decision and illustrates the option value of waiting. Because the probability that the pension assets increase to L is higher for sponsors with more volatile pension assets, these sponsors prefer to wait instead of conducting the PRT immediately.

While the numerical illustrations so far are in line with the predictions from Proposition 2, we now use our numerical approximations to examine the role of default risk. Because the simple model does not incorporate default risk, the blue line in the last panel is flat at approximately 95%. The black line in the last panel shows that a higher default risk makes the firm less inclined to conduct a PRT. The intuition behind this result is that higher default risk lowers a sponsor's planning horizon (which ends with default) and the present value of future pension costs decreases. Hence, an additional prediction from this section is that firms with higher default risk are less inclined to conduct a PRT.

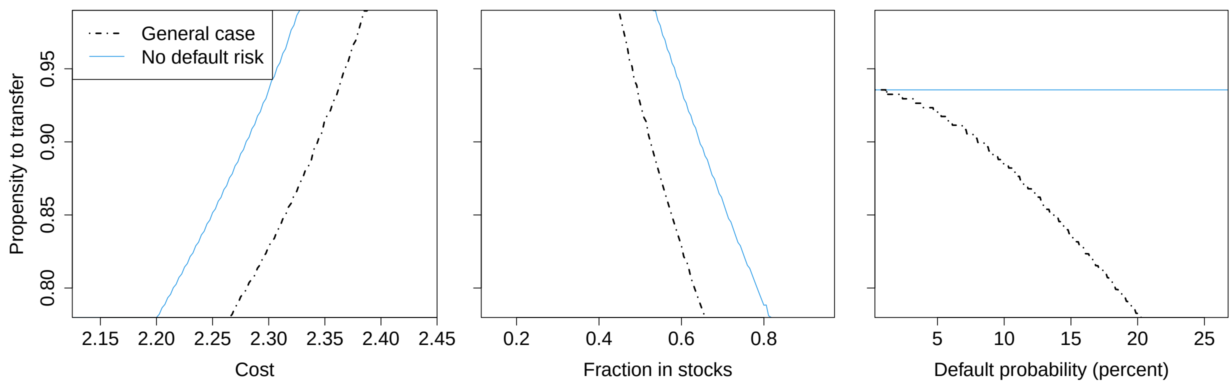

Figure 2: **Numerical illustrations.** This figure illustrates how the propensity of conducting a PRT varies for different values of Z, σ, and the propensity to default. The blue line corresponds to the propensity for conducting a PRT without default risk as defined in Equation (3) and the black line is a numerical approximation for the case with default risk. The baseline parameters are set as follows: $r = 0.03$, $\delta = \lambda = 0.01$, $\sigma_V = 0.175$, $\sigma = \sigma_V \times 0.6$, $V_0 = A_0 = 100$, $L = 120$, $Z = 92$, corresponding to a flow cost of 2.304%, and a default probability of 15.6%.

2.3 Summary of Theoretical Predictions

Before turning to the data, we summarize four testable predictions arising from our theoretical discussion. First and second, as shown in Proposition 2, we expect a higher propensity to conduct PRTs for firms with higher pension-related costs and for firms with lower equity allocations. Third, despite not having a closed-form solution for the general case, our numerical illustrations suggest that firms with less default risk are more likely to conduct a PRT. Finally, when setting up our model, we take L as exogenously given. In practice, L depends on the amount of inactive plan participants (as transferring inactive participants is most cost efficient) and we therefore test the additional hypothesis that sponsors are more likely to conduct a PRT if they have more inactive plan participants.

3 The Data

Because the huge PRTs by General Motors and Verizon in 2012 mark the start date of increased PRT activity, we restrict our sampling of PRTs to the 2012 to 2020 period and since we later use pension plan characteristics in year t to predict the propensity to transfer in year $t + 1$, we also include 2011 in our sample of plan sponsors. We examine corporate pension sponsors that report their pension assets and projected benefit obligations (PBOs) to the Compustat corporate pension database and focus on sponsors that are headquartered in the U.S. and have less than five missing database entries during the 2011 to 2020 period.[5]

Next, we match the filtered database with detailed information on individual pension plans from the Department of Labor (DoL) 5500 filings. We focus on single-employer DB plans and only consider plans that report detailed information, such as asset holdings and sponsor name. In combining Compustat and DoL filings, we first match pension plans to firms based on the reported Employer Identification Number (EIN). To overcome the problem that the EIN in the DoL filings sometimes links to a subsidiary of the Compustat entity (e.g., Rauh et al., 2020), we use a fuzzy-name matching algorithm for the unmatched plans that we check manually. To ensure a good match between the Compustat sponsor and the DoL information, we compare the pension assets reported in Compustat to the pension assets reported in the DoL filings. For firms where the DoL assets are substantially below the Compustat pension assets, we manually check Exhibit 21 of their annual reports and search matching plans in DoL.[6]

[5]We drop sponsors located outside the U.S. because we later rely on the company's annual reports, which can differ substantially for foreign firms. In addition, as we explain in more detail in Section A.1 in the appendix, removing sponsor that do not report in more than five years does not affect our sample size substantially but has the benefit that we compare averages of different firm characteristics during similar periods.

[6]We provide additional details on our matching procedure in the appendix. Supporting the quality of our matching procedure, Figure A1 in the appendix compares the average pension assets reported in Compustat

Focusing on this matched sample of $1,251$ sponsors, we assemble a comprehensive database of pension risk transfers by combining three data sources. We purchase a hand-collected set of major PRTs from PIonline and obtain a proprietary set of PRTs from Goldman Sachs. Because these data providers might overlook PRTs by smaller companies in our sample, we also use textual analysis and search the annual reports of firms in our matched sample for information on a conducted PRT. We relegate the details of this procedure to Section A.2 in the appendix and note that our approach enables us to construct a control sample of firms that are in the matched database but do not conduct a PRT during our sample period. The resulting PRT sample comprises 149 risk transfers conducted by 121 different companies and we therefore have a control sample of 1130 sponsors that did not conduct any PRTs during our sample period.

3.1 Stylized Facts

Panel A of Table 2 provides cross-sectional summary statistics of the four key variables in our analysis. For variables that fluctuate over time, we first compute time series average during the 2011 to 2019 period on the company level and then report cross-sectional summary statistics. Throughout the paper, we mitigate the potential impact of large outliers in the data by winsorizing all continuous variables at the 1% and 99% quantile. In addition to the cross-sectional summary statistics for the full sample, we also report the mean and median difference between firms that conducted at least one PRT during our sample period and the rest of our sample for the indicated variables. This simple comparison helps us establish a set of stylized facts that motivates our analysis and we examine these facts more closely in the following section, where we test the effect of additional controls and also explore the

to the market value of plan assets that we hand-matched from the DoL filings and suggests that most observations align on the 45 degree line.

Table 2: **Summary statistics.** *Panel A* provides summary statistics of average firm and pension plan characteristics, where we first compute the time series average for each firm in the 2010-2019 period and then report cross-sectional summary statistics. Under *Difference between firms with and without PRTs*, we report the mean and median difference between firms that conduct at least on PRT during the 2010-2020 period and the other firms in our sample. ***, **, and * indicate significance at a 1%, 5%, and 10% level, respectively, where the p-values for this calculation are based on a t-test for difference in means or a Wilcox test for difference in medians. For a detailed description of these variables see Table A3. *Panel B* provides summary statistics for the PRTs in our sample, where we aggregate transfers on the firm-year level.

Panel A: Sponsor and plan characteristics for the full sample

	Mean	SD	25%	Median	75%	N	*Difference between firms with and without PRTs* Diff. from Mean	Diff. from Median
$\sigma(UFA)$	2.22	2.68	0.34	1.36	3.00	1,032	2.27***	2.44***
$Allocation^{Eq\%}$	46.37	17.06	35.87	48.71	58.98	1,162	-6.62***	-8.33***
EDF	0.85	2.60	0.05	0.18	0.46	1,019	-0.38**	-0.12***
$Inactive^{\%}$	64.10	20.19	50.36	66.14	79.82	877	9.58***	11.88***
Firms with PRT	0.10					1,251		

Panel B: Overview of PRT sample

	N	USD transferred (mn) mean	total	N	Perc. of PBOs mean	N	Transferred participants mean	total	N
Full sample	149	787.2	102,336	130	19.93	129	9,618	1,086,835	113
GS or PIonline	84	1,256.6	96,762	77	24.09	77	14,643	951,786	65
Reports	65	105.2	5,574	53	13.77	52	2,814	135,049	48

time series dimension.

First, $\sigma(UFA)$ is a proxy for the macroeconomic risks faced by a given sponsor and measured as the standard deviation of the following variable over the 2000 to 2009 period:

$$UFA := \frac{\text{Projected Benefit Obligations} - \text{Pension Plan Assets}}{\text{Book Value of Firm Assets}}. \tag{6}$$

The table shows a large cross-sectional variation in $\sigma(UFA)$, ranging from a 25% quantile of 0.34 to a 75% quantile of 3.00. In addition, the mean (median) difference between firms that did and did not conduct a PRT during the sample period is 2.27 (2.44), suggesting that the firms with PRTs are exposed to substantially higher macroeconomic risk. Second, $Allocation^{Eq\%}$ is the percentage allocation of pension assets to equities and Panel B suggests that sponsors conducting a PRT have a 6.62 percentage points lower equity allocation. Third, EDF is the expected default frequency as estimated by the Moody's Analytics Public EDF model and provided to us curtsy to Moody's Analytics. The EDF captures a companie's default probability over the next year and ranges from a 25% quantile of 0.05 to a 75% quantile of 0.46 with firms conducting at least one PRT having a lower EDF than the control sample.[7] Finally, $Inactive^{\%}$ is based on data from DoL and captures the percentage of inactive plan participants. As shown in the table, more than half the DB plan participants are inactive with firms that conduct a PRT having approximately 10 percentage points more inactive participants. The last row of Panel B shows that a total of 10% of the firms in our sample conducted at least one PRT in the 2012 to 2020 period and we relegate summary statistics of other variables to the appendix (Table A4).

3.2 The Sample of Pension Risk Transfers

Panel B of Table 2 provides summary statistics of the individual transactions and shows that, out of the 149 PRTs, we extracted 65 observations from annual reports that were not mentioned either in the PIonline or Goldman Sachs database. For 130 of the transfers, we have information on the transfer size, which is on average \$787 million and varies between \$1,256 million for the transfers captured by PIonline or Goldman Sachs and \$105 million for the transfers obtained by searching through annual reports. This stark difference confirms our intuition that PIonline and Goldman Sachs mainly capture large PRTs that generate

[7] The large difference between mean and median suggest that there are some large outliers in the EDF sample. To avoid our results being driven by large outliers in the EDF measure, we use $\log(EDF)$ in our empirical analysis.

headlines in the financial press. In total, the companies in our sample have transferred more than \$100 billion of their pension obligations and, on average, 20% of the PBOs are transferred in a typical PRT, confirming that sponsors do not transfer their entire plans. Panel B also shows that we have information on the number of affected plan participants for subsample of 113 transfers and that the average number of affected participants is $9,618$ in a given transfer.[8]

The total amount of transferred liabilities and affected participants equals approximately 4% of the outstanding PBOs in our sample and 7% of the participants. While these fractions are relatively low, it is worth noting that PRTs target a sub-group of participants with lower PBOs and hence the fraction of affected participants among inactive participants is likely higher. Moreover, as discussed before, PRTs are becoming increasingly more popular as many corporate sponsors consider completely offloading their pension liabilities within the next years (MetLife, 2021).

4 Empirical Drivers of Pension Risk Transfers

We now conduct three tests of our model predictions. First, we focus on the propensity that a firm executes at least one PRT during our sample period and examine the robustness of our stylized facts in logistic regressions. Second, we test how firms that conduct a PRT in year $t+1$ differ from comparable firms that conduct no PRTs, measuring these differences in year t. Finally, we exploit the full panel dimension of our data and test how firm characteristics

[8]To be precise, we directly obtain the number of affected plan participants for 63 transfers. We then construct a proxy of transferred plan participants as the difference between the number of plan participants at the beginning of the reporting year and at the end of the reporting year, subtracting the number of participants that received lump sum payments. For the sample in which we have both the observed numbers and our proxy, the correlation between the two variables is 76% and we set the number of affected participants equal to our proxy for the transfers where this number is available.

in year t affect the odds of conducting a PRT in year $t+1$.

4.1 Cross-Sectional Analysis

We regress an indicator variable that equals one if a firm conducts at least one PRT during the 2012 to 2020 period on $\sigma(UFA)$, which is computed for the 2000 to 2009 period, and other variables averaged over the 2011 to 2019 period. Our cross-sectional regression is then set up as

$$\begin{aligned} \text{logit}(PRT_i) = \beta^{UFA}\sigma(UFA)_i + \beta^{Eq}Equity_i^{\%} + \beta^{EDF}\log(EDF_i) + \\ + \beta^{Inact}Inact_i^{\%} + \gamma Controls_i + \varepsilon_i. \end{aligned} \tag{7}$$

In Equation (7), we first test Proposition 2 by examining the impact of macro-risks, as captured by the volatility firm i's funding status ($\sigma(UFA)_i$), and the proportion of pension assets allocated to equity ($Equity_i^{\%}$). We then test the additional model prediction that firms with higher default risk, empirically proxied by $\log(EDF_i)$, have a lower propensity to conduct a PRT and finally examine the role of inactive plan participants ($Inact_i^{\%}$), which should increase the propensity to conduct a PRT. Because EDF_i and $Inact_i^{\%}$ are only available for a subset of firms, we first explore the robustness of our main results to adding more controls variables and examine the role of default risk and inactive participants afterwards.

Focusing first on the baseline results without controlling for $\log(EDF_i)$, Column (1) of Table 3 confirms our stylized fact and shows that, in line with Proposition 2, firms with higher $\sigma(UFA)$ and lower equity allocations are more likely to conduct at least one PRT during our sample period. Strikingly, a one percentage point increase in $\sigma(UFA)$ increases the odds of a PRT by 24.48% ($e^{0.219} - 1 = 0.2448$). Moreover, computing McFadden's pseudo R^2 shows that the two variables suggested by our theory explain more than 9% of the cross-sectional variation in the odds of conducting a PRT.

To examine if it is indeed the macroeconomic *pension risks* that drive the results, we next control for the volatility of the sponsoring firm's asset values and earnings during the 2000 to 2009 period and the average UFA measured both during the 2000 to 2009 and the 2011 to 2019 period. As shown in Column (2), adding these four controls leaves the regression coefficients of our main variables largely unchanged. Because the adjusted pseudo R^2 drops after adding them and because none of the additional controls is statistically significant, we omit the coefficient estimates in Table 3.

Next, we focus on four alternative controls that can affect the propensity to conduct a PRT. First, the underfunded ratio (UFR), which is the difference between plan liabilities and plan assets, divided by plan assets. While this variable is conceptually similar to UFA, it captures a plan's relative underfunding instead of normalizing by the sponsoring firm's size and therefore proxies the cost of conducting a PRT on the plan level. Second, the size of the pension obligations as fraction of firm assets ($PBO^{\%}$). Third, the ratio of debt to firm assets ($Debt$), which can be an alternative proxy of riskiness. Finally, the book value of the sponsoring firm's assets ($\log(Firm)$). As shown in Column (3), adding these controls leads to a marginal drop in the statistical and economic significance of our main variables and firms with more pension obligations or larger firms are more likely to conduct a PRT. While the coefficients for UFR and $Debt$ are not statistically significant, the table suggests that firms with more severe underfunding and more debt tend to be less likely to conduct a PRT and we examine these properties more closely in the following sections.

Column (4) shows that the statistical and economic significance of $\sigma(UFA)$ and $Equity^{\%}$ remains virtually unchanged when controlling for $\log(EDF_i)$ and restricting the analysis

Table 3: **Cross sectional logistic regression for the likelihood of a PRT.** This table shows the results from logistic regressions of the propensity that a given firm conducts at least one PRT during the 2012 to 2020 period. $\sigma(UFA)$ is the standard deviation of underfunded plan assets as percentage of firm value during the 2000 to 2009 period. Unless specified otherwise, all independent variables are averaged over the 2011 to 2019 period. For a detailed description of these variables see Table A3. Add. 2000-2009 contr. include the average UFA during 2011 to 2019, $\overline{UFA}$, $\sigma(\log(Firm))$, and $\sigma(\log(Earnings))$, all measured during the 2000 to 2009 period as additional controls. ***, **, and * indicate significance at a 1%, 5%, and 10% level, respectively. The numbers in parantheses show heteroskedasticy robust standard errors.

	(1)	(2)	(3)	(4)	(5)	(6)
$\sigma(UFA)$	0.219***	0.172***	0.127***	0.128**	0.131**	0.125**
	(0.031)	(0.044)	(0.049)	(0.053)	(0.052)	(0.057)
$Allocation^{Eq\%}$	−0.024***	−0.024***	−0.022***	−0.023***	−0.022***	−0.024***
	(0.005)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
$\log(EDF)$				−0.182**		−0.200**
				(0.081)		(0.083)
$Inactive^{\%}$					0.014**	0.013*
					(0.006)	(0.006)
UFR			−0.005	−0.010*	−0.002	−0.007
			(0.006)	(0.006)	(0.007)	(0.007)
$PBO^{\%}$			0.021***	0.019***	0.013*	0.013
			(0.007)	(0.007)	(0.007)	(0.008)
$Debt$			−0.006	−0.003	−0.005	−0.005
			(0.006)	(0.007)	(0.006)	(0.008)
$\log(Firm)$			0.157***	0.085	0.107*	0.029
			(0.057)	(0.068)	(0.060)	(0.070)
McFadden's ajd. R^2	0.091	0.085	0.104	0.102	0.091	0.085
Add. 2000-2009 contr.	No	Yes	No	No	No	No
Num. obs.	971	963	971	799	750	626

to the subsample with EDF data. In line with our additional model prediction, Column (4) shows that firms with higher default probabilities are less likely to conduct a PRT. Similarly, Column (5) shows that the statistical and economic significance of our two main variables remains unchanged when we control for $Inactive_i^{\%}$ and restrict our analysis to the subsample with data on inactive participants. In addition, Column (5) shows that firms with more inactive employees are significantly more likely to conduct a PRT. Finally, Column (6) shows that $\sigma(UFA)$ and $Allocation^{Eq\%}$ together with $\log(EDF_i)$ and $Inactive_i^{\%}$ are the only significant explanatory variables when we focus on the subsample with data on both EDFs and inactive employees.

4.2 Firm Characteristics Before Conducting a PRT

While the results from Section 4.1 provide evidence in favor of our main hypotheses, we now address a potential concern in this analysis: Using the average firm characteristics over the 2012 to 2020 period combines information before the PRT with information that is only available in hindsight. To overcome this potential look-ahead bias, we now incorporate the time series dimension in our analysis, focus on the year before a company conducts a PRT, and examine the differences between PRT firms and comparable firms without PRTs. We use two alternative approaches to capture comparable firms. First, for each firm that conducts a PRT in year $t + 1$, we take cross-sectional averages of firms without PRTs in the same industry, using the first two digits of their SIC code, and match these averages to the firm in year t. Second, we repeat this procedure with firms of comparable size, putting firms into deciles based on the book value of their assets in each year. Although $\sigma(UFA)$ is constant over time, we first focus on $\sigma(UFA)$, $Allocation^{Eq\%}$, $\log(EDF_i)$, and $Inactive^{\%}$. Afterwards we also examine the funding status (UFR) and the debt level ($Debt$) as alternative proxy for riskiness.

Starting with $\sigma(UFA)$, the first row of Table 4 confirms our earlier results and shows that firms which conduct a PRT in the following year face substantially higher macroeconomic pension risks. Turning to the allocation to equity, the second row of Table 4 shows that sponsors who transfer their plans are also invested in less risky pension assets, measured by

Table 4: **Matched differences.** This table illustrates how firms that conduct a PRT differ from firms that do not conduct a PRT. Under *Relative to industry*, we report the average difference in the indicated variables between firms that conduct a PRT in the following year and the average firm in our control sample that does not conduct a PRT during our sample period and is within the same industry (measured by the first two digits of the SIC code). Under *Relative to comparable size*, we report the average difference in the indicated variables between firms that conduct a PRT in the following year and the average firm in our control sample that does not conduct a PRT during our sample period and whose book value of firm assets is comparable (measured by size deciles). N is the number of observations and the numbers in parantheses are p-values of either a t-test (for means) or a Wilcox test (for medians) of the difference. ***, **, and * indicate significance at a 1%, 5%, and 10% level, respectively.

	Relative to industry			*Relative to comparable size*		
	Diff. from Mean	Diff. from Median	N	Diff. from Mean	Diff. from Median	N
$\sigma(UFA)$	1.96***	1.01***	141	2.75***	1.96***	141
	(0.000)	(0.000)		(0.000)	(0.000)	
$Allocation^{Eq\%}$	-10.08***	-8.01***	143	-10.41***	-7.22***	143
	(0.000)	(0.000)		(0.000)	(0.000)	
$\log(EDF)$	-0.55***	-0.77***	120	-0.34*	-0.78***	120
	(0.004)	(0.000)		(0.098)	(0.000)	
$Inactive^{\%}$	6.20***	9.10***	134	10.15***	15.71***	134
	(0.000)	(0.000)		(0.000)	(0.000)	
$Debt$	-5.98***	-4.69***	148	-3.56***	-2.07**	148
	(0.000)	(0.000)		(0.009)	(0.037)	
UFR	-4.67***	-4.20***	148	-1.48	-2.20	148
	(0.004)	(0.002)		(0.303)	(0.229)	

the fraction of plan assets invested in equities. On average, firms conducting a PRT in the following year invest 10.08 and 10.41 percentage points less in equities when compared to industry peers and firms of similar size, respectively. Using EDFs to asses a firm's riskiness, the third row of Table 4 shows that firms conducting a PRT have a lower default risk compared to industry and size peers. Next, examining $Inactive^{\%}$, we find that plans that conduct a PRT in the following year have a higher fraction of inactive employees. Returning to measures of riskiness, the fifth row of Table 4 shows that firms conducting a PRT have less leverage, measured as the fraction of debt to firm assets, compared to their peers. Finally, we examine whether companies conducting a PRT differ in terms of their level of underfunding and the last row of Table 4 shows that this measure is significantly lower for firms conducting a PRT in year $t+1$, both compared to industry peers and firms with comparable PBOs.

4.3 Panel Analysis

To examine the robustness of our findings to additional controls, we run predictive regressions of firm i conducting a PRT in year $t+1$ on explanatory variables in year t

$$\begin{aligned}\operatorname{logit}(PRT_{i,t+1}) = \beta^{UFA}\sigma(UFA)_i + \beta^{Eq}Equity^{\%}_{i,t} + \beta^{EDF}\log(EDF_{i,t}) + \\ + \beta^{Inact}Inact^{\%}_{i,t} + \gamma Controls_{i,t} + \varepsilon_{i,t}.\end{aligned} \tag{8}$$

As before, we first examine the role of underfunding risk and equity allocations, and test the effects of EDFs and inactive employees afterwards. Because we now have a panel of observations, we add year fixed effects to absorb the time trend in our sample (the number of PRTs increased substantially during our sample period) and industry fixed effects to compare firms within the same industry.

Starting with $\sigma(UFA)$ and $Equity^{\%}$, Column (1) of Table 5 confirms our earlier results and shows that firms with more macroeconomic pension risk and less risky pension assets are more likely to conduct a PRT. We next add UFR, $PBO^{\%}$, $Debt$ and $\log(Firm)$ as controls and Column (2) shows that adding these controls has no substantial effect on the statistical and economic significance of our main variables. In addition, Column (2) reveals that firms with more underfunded plans and more debt are less likely to conduct a PRT.

Next, we add $\log(EDF_{i,t})$ as control and Column (3) shows that focusing on the subsample with available EDF data leaves the statistical and economic significance of $\sigma(UFA)$ and $Equity^{\%}$ virtually unchanged. In contrast to our analysis from Section 4.1, the EDF measure

Table 5: **Logistic regressions for the likelihood of a PRT.** This table shows the results from logistic regressions of the propensity that a given firm conducts a PRT in year $t+1$. $\sigma(UFA)$ is the standard deviation of underfunded plan assets as percentage of firm value during the 2000 to 2009 period. All other independent variables are observed in year t. For a detailed description of these variables see Table A3. All specifications include year fixed effects and industry fixed effects (measured by the first two digits of the SIC code). ***, **, and * indicate significance at a 1%, 5%, and 10% level, respectively. The numbers in parantheses show heteroskedasticy robust standard errors, clustered at the firm level.

	(1)	(2)	(3)	(4)	(5)	(6)
$\sigma(UFA)$	0.154***	0.111**	0.124**	0.114***	0.131***	0.113***
	(0.030)	(0.044)	(0.052)	(0.039)	(0.044)	(0.043)
$Allocation^{Eq\%}$	−0.023***	−0.021***	−0.021***	−0.020***	−0.020***	−0.020***
	(0.005)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
$\log(EDF)$			0.003		0.040	0.010
			(0.080)		(0.075)	(0.080)
$Inactive^{\%}$				0.017***	0.014**	0.011
				(0.006)	(0.007)	(0.008)
UFR		−0.012**	−0.011*	−0.012	−0.011	−0.010
		(0.006)	(0.006)	(0.009)	(0.010)	(0.010)
$PBO^{\%}$		0.007	0.004	0.000	−0.003	−0.008
		(0.006)	(0.007)	(0.005)	(0.005)	(0.008)
$Debt$		−0.015**	−0.018**	−0.016**	−0.021**	−0.020**
		(0.006)	(0.008)	(0.007)	(0.009)	(0.009)
$\log(Firm)$		0.209***	0.192**	0.175**	0.169**	0.162**
		(0.065)	(0.081)	(0.070)	(0.083)	(0.082)
$Frozen$						0.276
						(0.256)
lump sums						0.006
						(0.006)
$DB^{\%}$						0.021
						(0.013)
$Cost\ ex^{\%}$						−0.071
						(0.148)
$PBGC^{\%}$						0.056
						(0.339)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	No
Firm FE	No	No	No	No	No	Yes
McFadden's ajd. R^2	0.113	0.124	0.098	0.103	0.075	0.069
Num. obs.	7820	7805	6383	5870	4867	4756

is not statistically significant in this specification. However, in this specification, *Debt* as an alternative proxy of riskiness is statistically significant with the expected sign. Focusing next on the role of inactive employees, Column (4) confirms that firms with more inactive employees in a given year are more likely to conduct a PRT the following year. Column (5) shows that combining inactive employees and the EDF measure as controls leaves our results largely unchanged with $\sigma(UFA)$, $Allocation^{Eq\%}$, $Inactive^{\%}$ and *Debt* as the main drivers of PRTs.

We conclude by exploring the role of two additional sets of controls. First, we control for other measures of pension de-risking to examine if it is simply a company's de-risking strategy that drives the decision to conduct a PRT. To that end, we construct an indicator variable that equals one if a given plan is frozen ($Frozen$). Because plan details come from the DoL data and one firm can sponsor multiple plans, we take the average of this indicator across plans under the same sponsor. We also control for the sum of employees that received lump sum buyouts, measured as fraction of all inactive employees (*lump Sum*), and proxy the transition to DC plans as the fraction of DB plan participants, divided by the number of employees reported by the sponsor ($DB^{\%}$). Second we control for more direct proxies of pension-related costs. Because we do not observe the PBGC premiums in the data, we construct a proxy for this variable ($PBGC^{\%}$), which we describe in more detail in Appendix A.3. Since PBGC premiums can be a substantial part of a company's pension-related costs, we mitigate multicolinearity concerns by subtracting the estimated PBGC premium from the aggregate pension-related costs and control for $Cost\ Ex^{\%}$. As shown in Column (6), out of the five additional controls none are statistically significant and, apart from a decrease in the statistical significance of the fraction of inactive participants, adding these controls leaves the coefficient estimates on our main variables virtually unchanged, confirming the robustness of our findings.

5 Implications of Pension Risk Transfers

While we focused so far on the motives for conducting a PRT from the perspective of the sponsor, we now discuss the implications of PRTs in a broader context. Starting with the perspective of the PBGC, we examine the impact of PRTs on the size and composition of the sponsors sponsor pool. Afterwards, we take a broader perspective and briefly discuss the impact of PRTs for the life insurers taking on the pension liabilities and for the affected plan participants.

5.1 Implications for the PBGC

PRTs reduce the PBGC premium base and decrease the proportion of inactive participants (which are more likely transferred) in the pool. An additional issue is mentioned in a study by Mercer (2018): "the structure [of PBGC premiums] motivates healthy plan sponsors to exit, potentially leaving PBGC to insure an increasingly unhealthy pension universe with shrinking premium base." This concern resonates with our findings, which suggest that plans with less risky pension assets and less underfunding are more likely to conduct PRTs, thereby increasing the riskiness and underfunding status of the remaining pool.

To illustrate the effects of PRTs in our sample, we first compute the aggregate size of PBOs and the number of plan participants in our sample and then construct a counterfactual measure of PBOs and plan participants, assuming that the transferred PBOs and plan participants would have remained with the sponsor during our sample period. This assumption likely overestimates the effect because some participants might have left the plan for other

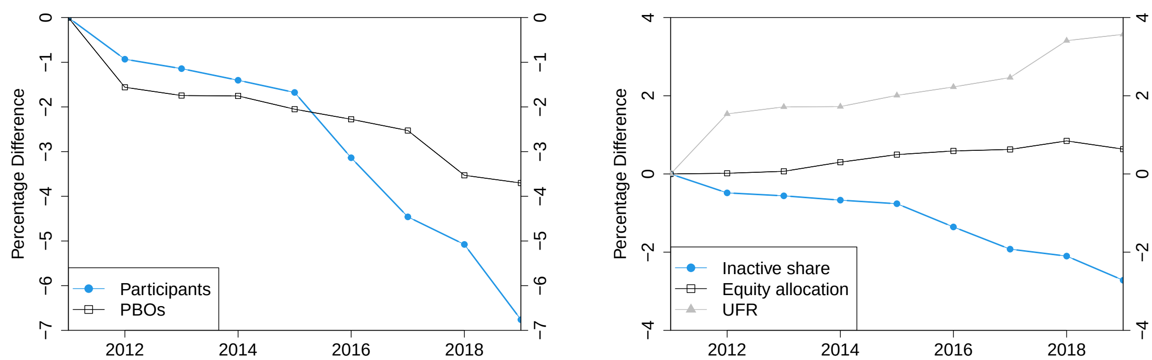

Figure 3: **Aggregate effects of PRTs.** This figure shows percentage differences between aggregate numbers for our sample and "counterfactual" numbers, where we add the transferred pension obligations or transferred participants back to the pool, implicitly assuming that they would have remained in the sample otherwise. The left hand graph shows the percentage differences in plan participants and PBOs. The right hand graph shows percentage differences in the share of inactive employees, the share of pension assets allocated to equities, and the aggregate underfunding in the pool. For each of these variables, we compute value-weighted sample averages, weighting the share of inactive participants with the total number of plan participants, the share of assets invested in stocks with the total amount of pension assets, and the underfunded ratio with plan PBOs.

reasons (e.g., decease) and hence our results are an upper bound of the effects. To illustrate the aggregate effect of PRTs, we compute the percentage difference between the observed values and our counterfactual values.

As shown in the first panel of Figure 3, PRTs lowered the size of PBOs in our sample by approximately 4% and the number of PBGC insured participants by approximately 7%. These findings suggest that the erosion of the PBGC base is higher compared to the aggregate amount of transfers, which is in line with the fact that sponsors focus on transferring inactive participants, whose PBOs are usually lower.

Next, we examine the fraction of inactive participants, the share of pension assets in equities, and the aggregate underfunding. For each variable, we compute the value-weighted sample average, weighting the share of inactive participants with the total number of plan participants, the share of assets invested in stocks with the total amount of pension assets, and the underfunded ratio with plan PBOs. To compute counterfactuals, we assume that all transferred participants were inactive and construct weighted averages for which we add back the transferred participants, pension assets, or PBOs. As shown in the second panel of Figure 3, the share if inactive participants is approximately 3% lower at the end of our sample period. In addition, the underfunding is approximately 4% higher and the effect on the riskiness of the remaining sample is relatively small with approximately 0.5%.

5.2 Additional Discussion

We conclude this section by briefly discussing the effects of PRTs for life insurers and affected participants.

Focusing first on the life insurers, they are arguably better equipped to handle pension-related risks than corporate sponsors for three reasons. First, similar to banks, insurance companies have expertise in managing financial portfolios and investments. Second, life insurers also have experience in managing long-duration assets because of their long-term liabilities which arise from offering life insurance policies. Finally, taking the responsibility for pension payments can serve as a natural longevity hedge for life insurers. To understand this argument, note that a longer life span benefits the traditional business model of life insurers because insurers receive premium payments from their customers until the customer passes away, in which case their insurance payment is due. By contrast, from the perspective of sponsoring DB obligations, a longer life span is costly for sponsoring DB pension obligations as the sponsor pays a fixed rate until the plan participant passes away.

Turning next to the plan participants, it is not clear whether a PRT improves the safety of their pension claims or makes the participants worse off. On the one hand, the life insurers conducting PRTs are well-capitalized and typically have a higher credit rating than the corporate sponsors. On the other hand, a recent Bloomberg article (Reyes, 2021) suggests that, despite the better credit quality, many retirees are skeptical about receiving their pensions from a different company. Part of this scepticism could come from the fact that the transferred pension obligations exit the PBGC system and become subject to state insurance, which is more difficult to understand and varies across states. In addition, MetLife recently discovered that it "had not paid about $13,500$ participants in its group annuity program over the past 25 years due to insufficient administrative practices" (Kozlowski, 2019), which can further increase the concerns of transferred plan participants.

6 Conclusion

We examine the choice of corporate DB pension plan sponsors to transfer their plans to life insurance companies theoretically and empirically. On the theory side, we model the choice of conducting a PRT as a real option exercise problem and find that firms are more likely to conduct a PRT if they are more exposed to macro-economic costs, hold less risky assets, and have a lower default probability. To test our model predictions, we focus on a sample of major corporate DB pension sponsors in the U.S., hand-collect information on whether these sponsors conduct PRTs (as well as PRT details if available), and construct a new measure of macro-economic risks, which is based on pre-crisis data. In line with our theory, our new measure of macro-economic pension risks together with a measure of pension plans' equity allocation, the fraction of inactive employees, and the sponsor's default probability are significant drivers of the propensity to conduct a PRT. These results point to a potential issue for the PBGC as safer plan sponsors tend to transfer their pension obligations.

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A Additional Details

This appendix contains details and additional results that we omitted in the body of the paper for brevity. Table A1 gives an overview of the different variables in our theory and Table A2 summarizes our parameter choices for the numerical illustrations. Table A3 contains a description of the variables used in our analysis. Table A4 presents summary statistics of other variables that were omitted in Table 2 in the body of the paper.

Table A1: **Variable definitions.** This table gives an overview of the variables used to derive our theory.

Symbol	Variable	Definition
A	Pension assets	$dA = (r-\delta)Adt + \sigma A dW^A$
A_U	Optimal exercises of PRT	Determined endogenously
τ	Exercise time of the PRT	$\tau = \text{argmin}\{t : A_t \geq A_U\}$
L	Pension liabilities	Constant
V	Firm assets	$dV = (r-\lambda)V dt + \sigma_V V dW^V$
V_B	Default boundary	
ν	Default time of firm	$\nu = \text{argmin}\{t : V_t \leq V_B\}$
D	perpetual debt with coupon c	$D = \frac{c}{r}\mathbb{E}^Q[1-e^{-r\nu}]$
E	firm equity	

Table A2: **Parameter choices.**

Paramter	Value	Explanation
r	0.03	risk-free rate
δ	0.01	
γ	0.01	
σ_V	17.5%	median asset volatility in our sample is 17.32%
σ	$0.6\sigma_V$	sponsor follows the 60% equity and 40% bonds rule
V_0	100	
L	120	median UFR is 20% in our sample
Z	92	gives a percentage cost of 2.3% and
		median percentage pension cost 2.3% in our sample
V_B	23	gives a default probability of 15.6%

Table A3: **Variable definitions.** This table defines the variables used in the empirical analysis.

Variable	Definition	Source(s)
$UFA(\%)$	Pension underfunding as percentage of firm assets (ticker: at). Pension unferfunding is defined as the difference between PBOs (ticker: pbpro) and plan assets (ticker: pplao)	Compustat & Compustat Pensions
$\sigma(UFA)$	Standard deviation of UFA during the 2000-2009 period	Compustat & Compustat Pensions
$Allocation^{Eq\%}$	Percentage allocation to equities in pension plan measured as ratio between pension allocation to equities (ticker: pnate) and total pension assets	Compustat Pensions
$Inactive^{\%}$	Number of inactive participants (either retired or terminated with vested benefits) as percentage of total plan participants. If a Compustat sponsor has more than one plan in the DoL filing, we aggregate the numbers on Compustat level	DoL 5500
EDF	Moody's Analytic's 1-year Expected Default Frequence, measured as the probability that the firm's assets drop to the default boundary.	Moody's Analytics
$Cost\ ex^{\%}$	Periodic pension costs from Compustat pensions (ticker: ppc) minus pension service costs (ticker: ppsc) as percentage of total firm assets	Compustat & Compustat Pensions
$PBGC^{\%}$	We estimate this number as the fixed-rate premium for each plan participant (total number of participants obtained from DoL) plus the floating rate premium multiplied with a proxy of UVBs, which we set to $[1 - Funding(\%)/100] \times Funding\ Target$ (fields: SB_Fndng_Tgt_Prcnt and SB_Fndng_Tgt_Amt)	DoL Schedule SB
$PBO^{\%}$	PBOs as percentage of firm assets	Compustat & Compustat Pensions
$\log(Firm)$	Logarithm of the book value of firm assets (ticker: at)	Compustat
$\overline{UFA}$	Average UFA during the 2000-2009 period	Compustat & Compustat Pensions
UFR (%)	Pension underfunding expressed as percentage of PBOs	Compustat Pensions

Debt	A companies total debt (ticker: dllt + dlc) as fraction of firm assets	Compustat
$\sigma(log(Firm))$	standard deviation of log($Firm$) during the 2000-2009 period	Compustat
Rating (num.)	Credit rating provided by Standard & Poor's and accessed through Compustat. *This variable is only available until 2017.* To obtain a numeric rating, we set AAA to 1, AAA- to 2, ..., D to 21. A value of 10 corresponds to BBB	Compustat (legacy)
Unrated	Indicator variable that equals one if a company does not have a credit rating in the entire 2012 to 2017 period	own calculations
$\#Participants$	Total number of participants (in thousands) in the DoL filings. If a Compustat sponsor has more than one plan in the DoL filing, we aggregate the numbers on Compustat level	DoL 5500
$lumpSum^{\%}$	"Number of participants (living or deceased) whose benefits were distributed in a single sum, during the plan year' (name: lumpSum_No)' as a percentage of all vested plan participants (name: Part_Vstd) at the beginning of the plan year	DoL Schedule R
Frozen	Indicator variable that equals one if a plan is frozen. We use the value-weighted (by assets) average of dummy variables if a sponsor has multiple plans. To obtain information on the status of the plan, we use the field TYPE_PENSION_BNFT_CODE, which is filled with "1I" if a given plan is frozen	DoL 5500 and Schedule H

Table A4: **Summary statistics.** This table provides summary statistics of average firm and pension plan characteristics, where we first compute the time series average for each firm in the 2010-2019 period and then report cross-sectional summary statistics. Under *Difference between firms with and without PRTs*, we report the mean and median difference between firms that conduct at least on PRT during the 2010-2020 period and the other firms in our sample. ***, **, and * indicate significance at a 1%, 5%, and 10% level, respectively, where the p-values for this calculation are based on a t-test for difference in means or a Wilcox test for difference in medians. For a detailed description of these variables see Table A3.

							Difference between firms with and without PRTs	
	Mean	SD	25%	Median	75%	N	Diff. from Mean	Diff. from Median
$\overline{UFA}$	2.05	3.26	0.23	1.13	2.92	1,055	1.87***	2.17***
$\sigma(\log(Firm))$	0.27	0.19	0.14	0.23	0.35	1,061	-0.02	0.02
$Cost^{\%}$	0.34	0.46	0.04	0.18	0.48	1,229	0.42***	0.43***
$Cost^{\%}$ (rel. to PENS assets)	2.21	1.80	1.04	2.23	3.41	1,115	0.46***	0.56**
UFA (%)	3.07	4.46	0.31	1.41	4.09	1,251	3.21***	2.87***
UFR (%)	20.72	18.16	11.50	20.34	29.64	1,251	-2.33*	-0.72
PBO to firm assets	14.73	18.92	2.34	7.76	19.30	1,251	18.29***	17.73***
log(Firm size)	8.33	1.75	7.18	8.29	9.41	1,251	0.33**	0.20**
Rating (numeric)	10.93	3.14	8.75	10.34	13.48	796	0.36	0.62
Unrated	0.36	0.48	0.00	0.00	1.00	1,251	-0.19***	0.00***
$\#Participants$	18.55	50.71	1.10	3.90	13.13	877	20.72***	9.42***
$lumpSum^{\%}$	11.84	15.18	3.38	8.03	14.28	877	0.38	2.35***
PBGC$^{\%}$	0.23	0.39	0.03	0.09	0.24	877	0.24***	0.18***
$DB^{\%}$	10.49	9.74	3.78	7.99	14.05	808	2.49**	1.44**
Frozen	0.35					868	-0.01	0.01

A.1 Sample Construction

The first two columns of Table A5 show the number of reporting firms and aggregate PBOs in each calendar year. We then apply three filters to our dataset. First, we drop firms that are headquartered outside the U.S. because we later collect information of PRTs from annual reports filed in EDGAR. As shown in columns 3 and 4, this leads to a drop of approximately 400 firms every year and reduces the aggregate PBOs in our sample by approximately 40%. Second, we drop firms with less than six consecutive years of reporting. We require a minimum of consecutive observations because we later use averages over our sample period and large reporting gaps can bias these estimates. While this filter seems like a stringent criterion, Table A5 shows that it only results in dropping smaller firms and a drop of approximately 10% of pension assets. Third, because we need a proxy for the breakdown between active and inactive employees, we match the Compustat data to detailed information on individual pension plans from the Department of Labor (DoL) 5500 filings. As we can see from the last two columns of Table A5, we are able to match the majority of firms in our restricted sample, especially when taking the aggregate pension assets as criterion.

The DoL requires each pension plan to file annual reports in their 5500 filings. We focus on single-employer DB plans and only consider plans that report detailed information, such as asset holdings and sponsor name.[9] In matching Compustat to the DoL, we proceed in three steps. First, we match pension plans to firms based on the reported Employer Identification Number (EIN). As noted by Rauh et al. (2020), the problem with this approach is that the EIN in the DoL filings sometimes links to a subsidiary of the Compustat entity.

[9]This type of reporting is mandatory for large plans and excluding plans without this type of reporting has a second-order effect. More specifically, we focus on plans filing Schedule H and Schedule R (9X% filing Schedule H also file Schedule R) because we need additional information on retirees and lump sum payments).

Table A5: **Sample selection.** This table illustrates our sample selection process. First, we find all firms that report positive pension plan assets and PBOs in Compustat Pensions (All Firms). Second, we focus on firms that are incorporated in the U.S. (U.S. only). Third, we focus on firms that report at least five observations during the 2011 to 2020 period (≥ 5 obs). Finally, we drop firms for which we are unable to find a match in the DoL filings (matched sample). N indicates the number of firms in each year and PBOs is the total projected benefit obligations in the respective sample. Under *All*, we report the total number of firms during the sample period and the total PBOs, measured as the sum of time series averages for all firms in the sample.

	All Firms		U.S. only		≥ 5 obs		Matched sample	
	N	PBOs	N	PBOs	N	PBOs	N	PBOs
2011	1,800	4,163.5	1,360	2,311.3	1,109	2,180.7	806	2,009.5
2012	1,805	4,655.9	1,353	2,542.6	1,142	2,415.0	823	2,221.2
2013	1,780	4,416.1	1,328	2,355.0	1,167	2,260.3	833	2,070.3
2014	1,762	4,709.2	1,313	2,637.2	1,197	2,540.2	850	2,317.9
2015	1,703	4,346.0	1,258	2,479.9	1,221	2,464.9	861	2,240.8
2016	1,626	4,490.2	1,189	2,534.5	1,161	2,520.1	870	2,294.2
2017	1,594	4,674.5	1,167	2,646.6	1,119	2,596.9	835	2,366.1
2018	1,539	4,331.4	1,129	2,416.0	1,062	2,369.2	797	2,149.8
2019	1,494	4,641.2	1,092	2,593.9	1,012	2,533.2	759	2,290.6
2020	1,428	4,838.4	1,043	2,780.6	963	2,715.8	723	2,452.6
All	2,223	4,967.729	1,663	2,787.0	1,257	2,570.1	877	2,304.8

Second, to overcome this problem, for the unmatched plans we use a fuzzy-name matching algorithm that we check manually, ensuring that the matched plans are indeed sponsored by the Compustat entity. To ensure the quality of our Compustat-DoL matching, we compare the pension assets reported in Compustat to the pension assets reported in the DoL filings. In a third step, for firms where the DoL assets are substantially below the Compustat pension assets, we manually check Exhibit 21 of their annual reports and search matching plans in DoL.

To check the quality of our matching procedure, Figure A1 in compares the average pension assets reported in Compustat to the market value of plan assets that we hand-

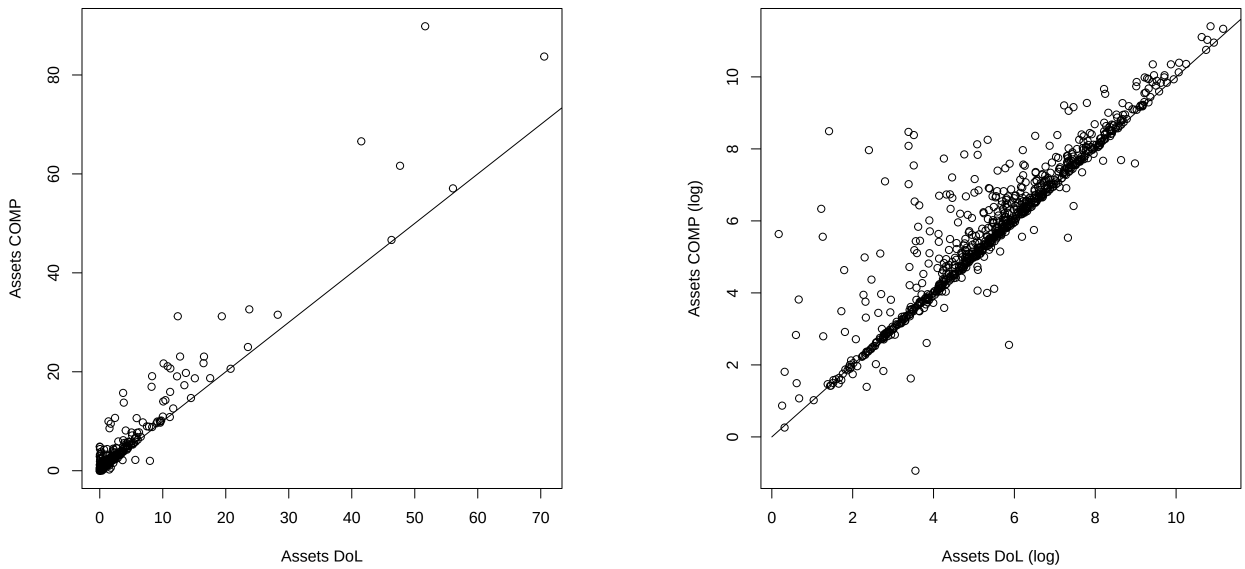

Figure A1: **Plausibility checks for our matching of Compustat pensions and DoL.** This figure compares the reported pension assets in Compustat pensions to the sum of matched plan assets from the DoL filings. We first compute averages over the full sample period and then compare the values.

matched from the DoL filings. While some imperfect matches, most firms align on the 45 degree line.

A.2 Obtaining PRT Information from Company's Balance Sheets

We assemble our database of PRTs by first merging the information from PIonline and from Goldman Sachs. However, because we examine the propensity to conduct a PRT, it is crucial that we capture *all* PRTs by the firms in our matched sample. One potential concern with the data from PIonline and Goldman Sachs is that they might overlook smaller PRTs or PRTs by smaller firms.

To address this concern, we use textual analysis and search the annual reports of all firms in our matched sample for information about potential PRTs, proceeding in three steps. First, we download the two sentences before and after each occurrence of the words "pension" or "retiree". Second, we filter these hits by focusing only on occurrences that include one of the following words in the two sentences before or after the first search word occurred: "annuity", "transfer", or "purchase agreement". We then manually check each of the observations to collect information on the size of the risk transfer, the affected retirees, and the involved insurance company.

A.3 Estimation of the PBGC Premium

Because companies do not directly report the premium paid to the PBGC, we estimate this premium using information from the DoL filings as follows. For firm i, we estimate the PBGC premium as the sum of a proxy for the flat and the variable part. For the flat part, we multiply the number of plan participants with the flat per-participant premium reported on the PBGC website. For the variable part, we approximate the unfunded vested benefits as:

$$UVB = (1 - Funding(\%)/100) \times Funding\ Target,$$

where Funding(%) and Funding Target are plan-level information from the DoL. More precisely, we use the fields SB_Fndng_Tgt_Prcnt and SB_Fndng_Tgt_Amt, which give a proxy of the UVB. However, it is important to note that this is an estimate that can differ from the true premium because the PBGC uses a different proxy for plan liabilities, which is not part of the DoL reporting. In the PBGC approach, only vested liabilities are counted and discounting rates can differ from those used in the DoL reporting.

Table A6 summarizes our proxies of the flat and variable premiums as fraction of firm assets.

Table A6: **Summary statistics of the approximated PBGC premiums.** This table provides summary statistics of our estimates of the flat-rate, variable-rate, and total PBGC premium. All variables are expressed as percentages of total firm assets. Under $Difference$, we report the mean and median difference between firms that conducted a PRT and the other firms in our sample.

							Difference	
	Mean	SD	25%	Median	75%	N	Mean	Median
Flat premium	0.10	0.14	0.02	0.05	0.13	818	0.08***	0.09***
Variable premium	0.13	0.27	0.01	0.04	0.11	818	0.17***	0.11***
Total PBGC	0.23	0.38	0.03	0.10	0.25	818	0.25***	0.21***

A.4 Where Do They Transfer To?

Table A7 contains summary statistics of where the corporate sponsors of DB plans transfer their liabilities to. The table shows that—to the extent that we can observe the counterparty—the transfers are clustered within a small number of insurance companies.

Table A7: **Summaries of where the companies transfer to.** This table contains summary statistics of the PRTs for which we observe the counterparty together with information on the counterparty. PRT Liabilities is the dollar amount that we observe was transferred to the insurance company during our sample period; #Transfers is the number of transfer that we observe to the insurance company during our sample period; Total Liabilities are the total liabilities of the insurance company at group level, as measured by AM Best; AM Best Financial Strength Rating is the rating of the insurance company according to AM Best.

Company	PRT Liabilities (Billion USD)	# Transfers	Total Liabilities (Billion USD)	AM Best Financial Strength Rating
Prudential	61.51	27	618.36	$A+$
MassMutual	4.39	12	301.23	$A++$
MetLife	14.71	12	410.12	$A+$
Athene	10.13	7	96.34	A
Legal & General	4.59	5	5.64	NA
AIG	2.20	4	298.85	A
PacificLife	0.20	3	142.39	$A+$
PrincipalFinancial	0.78	3	204.49	$A+$
Other	4.05	11		
Not disclosed	9.31	68		

A.5 Event Study Analysis

We use an event-study methodology to examine if there is a direct impact of PRT announcements on stock prices or CDS premiums. Table A8 shows little evidence of an immediate effect on CDS premiums or stock prices.

Table A8: **Stock returns and CDS premiums around PRT announcements.** This table shows the mean and median of (i) raw stock returns, (ii) stock returns adjusted for the 3 Fama-French factors (using betas estimated over the previous 12 months), and (iii) and log-changes in the CDS premium. The one day window is defined as changes or returns from one business day before the PRT announcement to one business day after the announcement. Similarly, the 5-day and 20-day windows are defined from 20 business days before to 20 business days after the announcement.

	1-day window			5-day window			20-day window		
	Ret	α^{FF}	$\Delta\log(CDS)$	*Ret*	α^{FF}	$\Delta\log(CDS)$	*Ret*	α^{FF}	$\Delta\log(CDS)$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
mean	0.106	-0.180	-0.432	0.881	-0.155	-1.382	0.619	-0.579	0.088
(p-value)	(0.818)	(0.678)	(0.343)	(0.149)	(0.791)	(0.198)	(0.483)	(0.447)	(0.953)
median	0.481	-0.047	0.000	0.819	-0.283	-0.207	0.275	-0.991	0.011
(p-value)	(0.393)	(0.832)	(0.176)	(0.206)	(0.517)	(0.147)	(0.455)	(0.465)	(0.961)
N	93	92	75	93	92	74	93	92	74

B Proofs and Additional Theoretical Results

This section contains the proofs of Propositions 1 and 2, a description of our numerical approximation method, and additional theoretical results that were omitted in the body of the paper.

B.1 Proofs and Additional technical results

To prove Propositions 1 and 2, we start by stating and proving the following two lemmata. The first lemma characterizes the propensity of hitting an upper or lower barrier a geometric Brownian motion.

Lemma 1. *For a geometric Brownian motion S_t with $dS_t = \mu S_t dt + \sigma S_t dW_t$, the propensity to hit a boundary S^B is given as:*

$$q(S_t) = \mathrm{E}^Q \left[e^{-r\tau} \right] = \left(\frac{S_t}{S^B} \right)^{\gamma}, \tag{9}$$

with $\gamma_{1,2} = \frac{-(\mu - \frac{\sigma^2}{2}) \pm \sqrt{(\mu - \frac{\sigma^2}{2})^2 + 2r\sigma^2}}{\sigma^2}$. The parameter γ depends on whether the boundary is hit from above (minus and $\gamma < 0$) or below (plus and $\gamma > 1$).

Lemma 2. *The parameter β, from Proposition 1 decreases in σ : $\frac{\partial \beta}{\partial \sigma} < 0$.*

Proof of Lemma 1: For a given S^B, we derive the propensity $q(S)$ to hit the barrier from below (analogous for hitting the barrier from above). Note that q is the value of one dollar paid at time τ (the time when the boundary is hit). We express q as claim on S_t and derive the following ordinary differential equation (ODE) for q :[10]

$$-rq + \mu S q_S + \frac{\sigma^2}{2} S^2 q_{SS} = 0 \tag{10}$$

with $q(S_B) = 1$ as boundary condition. We guess the solution $q(S) = aS^\gamma$ and plug it into (10) to obtain:

$$\gamma_{1,2} = \frac{-(\mu - \frac{\sigma^2}{2}) \pm \sqrt{(\mu - \frac{\sigma^2}{2})^2 + 2r\sigma^2}}{\sigma^2}. \tag{11}$$

Next, the boundary condition gives:

$$a(S^B)^\gamma = 1 \Leftrightarrow a = (S^B)^{-\gamma}$$

Hence, we get: $q(S) = \mathrm{E}^Q\left[e^{-r\tau}\right] = \left(\frac{S}{S^B}\right)^\gamma$.

Note that all steps so far are identical for hitting the boundary from below or above. However, the economics of the problem dictates which root we need. We need $\gamma_1 > 1$ for hitting the boundary from below and $\gamma_2 < 0$ for hitting the boundary from above, which completes the proof.

■

Proof of Lemma 2: Consider $\beta_{1,2}$ as function of σ and introduce the simplifying notation $\rho(\sigma) := r - \delta - \sigma^2/2$.

$$\beta_{1,2} = \frac{-\rho \pm \sqrt{\rho^2 + 2r\sigma^2}}{\sigma^2}.$$

[10]Note that the time dimension drops out because F is independent of time as in Leland's model

Use $\rho'(\sigma) = -\sigma$ and $\frac{\partial}{\partial\sigma}(\rho^2(\sigma)) = -2\sigma\rho$. Then, taking derivatives gives:

$$\beta'_{1,2} = \frac{\pm(r+\delta+\sigma^2/2)(\rho^2+2r\sigma^2)^{-1/2}}{\sigma} - \frac{1+2\beta}{\sigma}$$

From that, it is obvious that $\beta'_2 < 0$. To prove that $\beta'_1 < 0$, we exploit $\beta_1 \times \beta_2$ as follows:

$$\beta_1 \times \beta_2 = -\frac{2r}{\sigma^2} \Rightarrow \frac{\partial}{\partial\sigma}\beta_1 \times \beta_2 = \frac{\partial\beta_1}{\partial\sigma} \times \beta_2 + \frac{\partial\beta_2}{\partial\sigma} \times \beta_1 = \frac{4r}{\sigma^3}$$

Rearranging terms gives:

$$\begin{aligned} \frac{\partial\beta_2}{\partial\sigma} \times \beta_1 &= \frac{4r}{\sigma^3} - \frac{\partial\beta_1}{\partial\sigma} \times \beta_2 \\ \Leftrightarrow \frac{\partial\beta_1}{\partial\sigma} &= \underbrace{[\frac{4r}{\sigma^3} + \underbrace{(-\frac{\partial\beta_2}{\partial\sigma})}_{>0} \times \underbrace{\beta_1}_{>0}]}_{>0} / \underbrace{\beta_2}_{<0} < 0, \end{aligned}$$

which completes the proof.

■

Proof of Proposition 1: We start by simplifying Equation (3) and formulating the target function by dropping all terms that are independent of A_U:

$$f(A_U) = (Z - (L - A_U))\mathbb{E}^Q[e^{-r\tau}] = (Z - (L - A_U))\left(\frac{A}{A_U}\right)^{\beta}$$

Taking derivatives gives:

$$f'(A_U) = \left(\frac{A}{A_U}\right)^{\beta} - \beta\left(Z - (L - A_U)\right)\left(\frac{A}{A_U}\right)^{\beta}\frac{1}{A_U} = 0$$
$$\Leftrightarrow A_U = \frac{\beta}{(\beta - 1)}\left(L - Z\right) > L - Z.$$

Next, applying Lemma 1 gives the propensity to conduct the PRT:

$$q(A) = \mathrm{E}^Q\left[e^{-r\tau}\right] = \left(\frac{A}{A_U}\right)^{\beta} \text{ with}$$
$$\beta = \frac{-(r - \delta - \frac{\sigma^2}{2}) + \sqrt{(r - \delta - \frac{\sigma^2}{2})^2 + 2r\sigma^2}}{\sigma^2} > 1.$$

With that the propensity for a transfer is given as:

$$q(A) = \left(\frac{\beta - 1}{\beta}\frac{A}{L - Z}\right)^{\beta} = \left(\frac{A}{A_u}\right)^{\beta},$$

which completes the proof.

■

Proof of Proposition 2: To prove part (a), we take the derivative of q with respect to Z:

$$\frac{\partial q}{\partial Z} = \frac{\partial}{\partial Z}\left(\frac{\beta - 1}{\beta}A\right)^{\beta}(L - Z)^{-\beta} = \beta(L - Z)^{-\beta-1}\left(\frac{\beta - 1}{\beta}A\right)^{\beta} > 0$$

To prove part (b), we use Lemma 2, which states that $\partial\beta/\partial\sigma < 0$ and take the derivative of

q with respect to σ :

$$\frac{\partial q}{\partial \sigma} = \left[\frac{1}{\beta - 1} + \log\left(\frac{\beta - 1}{\beta}\frac{A}{L - Z}\right)\right] \underbrace{F\frac{\partial \beta}{\partial \sigma}}_{<0}$$

To complete the proof of part (b), we need to show that $\frac{1}{\beta-1} + \log\left(\frac{\beta-1}{\beta}\right) + \log\left(\frac{A}{L-Z}\right) > 0$. Because we can assume $A > L - Z$ (because $Z > L - A$, otherwise it would *never* be optimal to conduct the PRT), we can ignore the last term and examine $g(\beta) = \frac{1}{\beta-1} + \log(1 - 1/\beta)$. Here, we note that $g(\beta) \to 0$ for $\beta \to \infty$ and

$$g'(\beta) = -\frac{1}{(\beta - 1)^2} + \frac{1/\beta^2}{1 - 1/\beta} = -\frac{1}{(\beta - 1)^2} + \frac{1}{(\beta - 1)(\beta + 1)} = \frac{-(\beta + 1) + (\beta - 1)}{(\beta - 1)^2(\beta + 1)} < 0.$$

Therefore, for $\beta > 1$, we have $g(\beta) > 0$, which completes the proof.

To prove part (c), we take the derivative with respect to $L - Z$:

$$\frac{\partial F}{\partial (L - Z)} = \left(\frac{\beta - 1}{\beta}A\right)^{\beta} \frac{\partial}{\partial (L - Z)}(L - Z)^{-\beta} = -\beta(L - Z)^{-\beta-1}\left(\frac{\beta - 1}{\beta}V\right)^{\beta} < 0$$

Taken together, this completes the proof.

■

B.2 Numerical Approximations Procedure

To obtain numerical solutions, we compute the cumulative distribution functions (CDFs) of τ and ν, using the techniques outlined in Harrison (1990). We restate the relevant result in the following Lemma and refer to Harrison (1990) for a proof of this result.

Lemma 3. *Consider a Brownian motion X_t with mean μ, drift σ, and $X_0 = x_0$. Define τ_1 and τ_2 as the first time when X_t hits an upper boundary x or a lower boundary y. The corresponding CDFs are given as:*

$$\mathrm{P}(\tau_1 > t) = \Phi\left(\frac{x_0 - x + \mu t}{\sigma\sqrt{t}}\right) - e^{\frac{-2\mu(x_0 - x)}{\sigma^2}}\Phi\left(\frac{x - x_0 + \mu t}{\sigma\sqrt{t}}\right)$$
$$\mathrm{P}(\tau_2 > t) = \Phi\left(\frac{y - x_0 - \mu t}{\sigma\sqrt{t}}\right) - e^{\frac{-2\mu(y - x_0)}{\sigma^2}}\Phi\left(\frac{x_0 - y - \mu t}{\sigma\sqrt{t}}\right)$$

Using A or V, Lemma 3 allows us to simulate τ and ν. In the baseline case where A and V are independent, the simulation is straight-forward – we simulate uniformly distributed random variables and use the inverse of the CDFs to obtain simulations of τ and ν. To simulate correlated processes (as we do in Section B.4), we start by varying the correlation between the two uniformly distributed variables and illustrate the results as a function of the correlation between the simulated processes for τ and ν.

B.3 PBGC Premiums and the PBGC Put Option

We now consider the general case with default risk in more detail and examine how a wedge between the value of the PBGC put option and the present value of PBGC premium payments can arise from the perspective of the sponsoring firm. While the firm value after default does not enter the equity-maximizing decision directly because the equity value of the firm drops to zero in case of default, we now specify the recovery rate after default as αV_B, where $\alpha = \alpha_1 + \alpha_2$ is the sum of recovery values to creditors and PBGC. Under default, debt holders receive a payment of $\alpha_1 V_B$, the PBGC receives a payment of $\alpha_2 V_B$, and the equity value drops to zero.

We simplify the model by only considering a flat-rate premium make the plausible assumption that the PBGC chooses the flat insurance premium x per unit time without internalizing the possible PRTs of the DB sponsor. Under this assumption, the value of the PBGC put option from the perspective of the PBGC is given as:

$$E^Q[p(V;\nu)] = \mathbb{E}^Q\left[\int_0^\nu xe^{-rs}ds\right] + \alpha_2\mathbb{E}^Q\left[e^{-r\tau}\right], \tag{12}$$

where $p(V;\nu)$ denotes the price of a European put option with random maturity ν. The right-hand side of Equation (12) reflects the risk-neural expectation of the capitalized value of PBGC payments in solvent states, plus the risk-neural expected value of recoveries by PBGC under default is the expected value of the PBGC put. Applying Lemma 1 to Equation (12) and using the notation $X \equiv \frac{x}{r}$, we can derive the following proposition.

Proposition 3. *The fair insurance premium set by the PBGC satisfies:*

$$E^Q[p(V;\nu)] = \left(1 - \left[\frac{V_A}{V_B}\right]^\gamma\right)X + \left(\frac{V_A}{V_B}\right)^\gamma \alpha_2 V_B \tag{13}$$

where,

$$\gamma = \frac{-(r-\lambda-\frac{\sigma_V^2}{2}) - \sqrt{(r-\lambda)-\frac{\sigma_V^2}{2})^2 + 2r\sigma_V^2}}{\sigma_V^2} < 0.$$

and Note that $\left(\frac{V_A}{V_B}\right)^\gamma = \mathbb{E}^Q[e^{-r\nu}]$ is the risk-neutral probability of default and that Equation (13) can be thought of as the structural analogue of the formula in van Binsbergen et al. (2014).

We next make the simplifying assumption that $\alpha_2 = 0$, solve Equation (13) for X, and use the result to chacterize the potential wedge between the fair value of the PBGC put option from the perspective of the PBGC and the PBGC put option value from the perspective of the sponsoring firm. Denoting the potential wedge by M we get:

$$M \equiv E^Q[p(V;\nu)] - \underbrace{X\left(1 - \mathrm{E}^Q\left[e^{-r\tau\wedge\nu}\right]\right)}_{\text{Fair value from firm perspective}} = -E^Q[p(V;\nu)]\left\{\frac{\mathrm{E}^Q\left[e^{-r\nu}\right] - \mathrm{E}^Q\left[e^{-r\tau\wedge\nu}\right]}{\left(1 - \mathrm{E}^Q\left[e^{-r\nu}\right]\right)}\right\} > 0 \tag{14}$$

Thus, with just a flat PBGC premium, fixed for the life of the firm, the feedback effect of insurance premium is to delay the propensity of a PRT. But over the years, PBGC has increased the flat rate. In addition, PBGC has introduced a variable rate component reflecting the UVBs. This has increased sharply over recent times. Together, these two features can cause X can go up significantly for underfunded plans whose perception of the put value may not have materially changed over time. This will make $M < 0$ and will increase their propensity to do PRT. The wedge factor, M, which captures the difference between the value of the premiums paid by the firm and the value of the PBGC put depends on many of the underlying deep parameters. It is natural to think that a firm with more inactive plan participants will feel this wedge more acutely: it pays premium but do not get the services of these workers.

B.4 Additional Numerical Illustration

We next examine the impact of the correlation between firm assets and pension assets on the decision to conduct a PRT. When varying these parameters, the blue line remains flat because default risk is not part of the simple model. To understand the impact of the correlation between pension assets and firm assets on the PRT decision, we examine q as a function of the correlation between ν and τ. As shown in Figure A2, a negative correlation between the default event and the PRT decreases the firms' likelihood to conduct a PRT while q

converges to the baseline case for a positive correlation. The intuition behind this result is that a more negative correlation between these events means that V and A are positively correlated, which could be the case for firms whose pension assets are more exposed to the stock market.

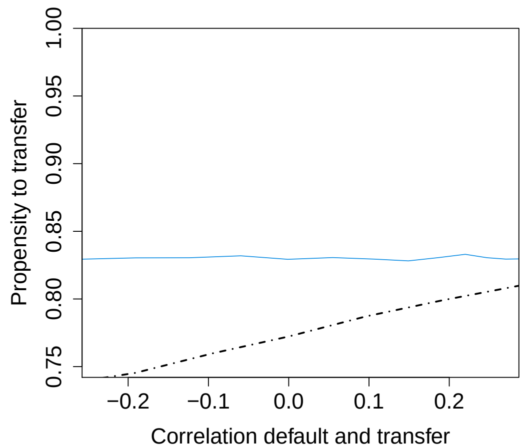

Figure A2: **Numerical illustration of the correlation between** A **and** V. This figure illustrates how the propensity of conducting a PRT varies for different correlations between the firm's assets and the pension plan assets. The blue line corresponds to the optimal asset value for conducting a PRT without default risk and is flat as fluctuations in firm assets do not affect the firm's propensity to transfer. The black line is a numerical approximation for the case with default risk. The baseline parameters are set as follows: $r = 0.03$, $\delta = c(\lambda) = 0.01$, $\sigma_V = 0.2$, $\sigma = 0.12$, $V_0 = A_0 = 100$, $L = 125$, $V_B = 20$, and $Z = 96$, corresponding to a flow cost of 2.304%.