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Do a firm's equity returns reflect the risk of its pension plan?☆

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Abstract

This paper examines the empirical question of whether systematic equity risk of US firms as measured by beta from the capital asset pricing model reflects the risk of their pension plans. There are a number of reasons to suspect that it might not. Chief among them is the opaque set of accounting rules used to report pension assets, liabilities, and expenses. Pension plan assets and liabilities are off-balance sheet and are often viewed as segregated from the rest of the firm, with its own trustees. Pension accounting rules are complicated. Furthermore, the role of the Pension Benefit Guaranty Corporation clouds the real relation between pension plan risk and firm equity risk. The empirical findings in this paper are consistent with the hypothesis that equity risk does reflect the risk of the firm's pension plan despite arcane accounting rules for pensions. This finding is consistent with informational efficiency of the capital markets. It also has implications for corporate finance practice in the determination of the cost of capital for capital budgeting. Standard procedure uses de-leveraged equity return betas to infer the cost of capital for operating assets. But the de-leveraged betas are not adjusted for the risk of the pension assets and liabilities. Failure to make this adjustment typically biases upward estimates of the discount rate for capital budgeting.

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The magnitude of the bias is shown here to be large for a number of well-known US companies. This bias can result in positive net present value projects being rejected.

JEL classifications: G14; G23; G31

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1. Introduction

In this paper, we examine the empirical question of whether real-world equity returns reflect the risk of corporate pension plans. We focus on the systematic risk of the firm and use beta from the Sharpe (1964) capital asset pricing model (CAPM) as the measure of such risk.[1]

Many reasons can be cited for why pension risk might not be reflected in equity returns. Pension plan assets and liabilities are off-balance sheet and are often viewed as segregated from the rest of the firm. Pension plans have their own trustees, and pension accounting rules are complicated. Furthermore, the role of the Pension Benefit Guaranty Corporation (PBGC) as guarantor of corporate pension benefits to employees complicates the relation between the risk of the pension plan and the risk of the firm equity.

A substantial literature in economics and finance studies value transparency, or whether pension assets and pension liabilities affect the market valuation of firms. Representative papers include Oldfield (1977), Feldstein and Seligman (1981), Feldstein and Morck (1983), Bodie et al. (1987), Bulow et al. (1987), and Bodie and Papke (1992). These papers provide considerable empirical evidence that the equity market valuation of firms takes into account the difference between the value of pension plan assets and its liabilities, i.e., the pension surplus or deficit (if that difference is negative). Carroll and Niehaus (1998) confirm those findings in a parallel test of debt market recognition of the value of the pension surplus or deficit by empirically examining the positive relation between funding of defined-benefit pension funds and debt ratings. Furthermore, in both equity and debt markets, there seems to be an asymmetric pattern in the impact of changes in pensions assets and liabilities on the market value of the firm and on debt ratings. While each dollar increase in liabilities lowers the market value of the firm by about a dollar, an equal increase in pension assets raises the firm's market value by less than a dollar. Similarly, a pension deficit reduces debt ratings by more than the same size pension surplus increases debt ratings. This is consistent with the view that, while an underfunded pension liability should be fully reflected as a corporate liability, overfunded pension assets are not entirely a corporate asset, because of the difficulty of converting an overfunded pension plan's assets into unencumbered corporate assets.

However, the literature has almost no analysis, either theoretical or empirical, about how the risk level of a defined-benefit pension plan affects the risk of the market value of the firm. As we shall see, value transparency does not necessarily imply risk transparency.

[1]Although the explicit measure of systematic risk used here is in the context of the CAPM, the same concept can be applied to multiple beta asset pricing models, such as the Fama and French three-factor model (1996), the Ross (1976) arbitrage pricing theory, and the intertemporal CAPM (Merton, 1992, Chapter 15). Also, we have focused on the systematic risk, although idiosyncratic risk, or the total risk, might be of some interest. Our data did not permit us to use these alternative measures of risk.

The former is a static measure, whereas the latter is a dynamic measure. To our knowledge, our paper is the first to focus on dynamic measurement by testing whether pension plan systematic risk is reflected in firm equity risk.

Given that estimates of beta play a pivotal role in performance evaluation and in the estimated cost of capital calculation, accurate estimation of beta is crucial. The question we address therefore has important implications for the correct calculation of operating asset beta and tests of market efficiency, regardless of the direction of the answer.

On the one hand, if pension risk is not accurately reflected in the firm's equity beta (which implies that the market is informationally inefficient), then standard analysis usually underestimates the true systematic risk of the firm. This underestimation of risk could lead to the appearance of superior corporate performance on a risk adjusted basis and that in turn would lead to a pattern of overvaluation of the firm.

On the other hand, if the firm's equity beta does accurately reflect its pension plan risk, it can have a significant implication for corporate finance in estimating a firm's cost of capital. The standard methodology for calculating the cost of capital treats it as a weighted average of the cost of equity and the after-tax cost of debt (which is the pre-tax cost of debt adjusted for the tax shield generated by the corporate debt). See, for example, Brealey and Myers (2002), Copeland and Weston (1992), Ross et al. (2002), and Van Horne and Wachowicz (1995). Such calculation implicitly neglects the pension plan, or, it assumes that the pension assets and liabilities have the same risk characteristics as the operating assets and therefore do not need to be counted separately. The plain facts are that pension plan assets and liabilities are substantial for many firms, and they would only coincidentally have the same risk characteristics as the operating assets. As will be demonstrated, large estimation biases for the firms' operating betas can exist in such cases.

In Section 2, we derive the theoretical asset beta for the firm's operating assets as a function of the firm's equity beta, pension asset beta, and debt and pension liability beta. From this, we derive the specification errors in the estimation of the operating asset beta if pension assets and liabilities are completely ignored, and if the value of the pension plan is correctly taken into account but not its risk. For a selected sample of firms we show as an empirical matter that the resulting overstatement of the cost of capital can be substantial. This section is based on Merton (2002). See also Merton (2004). In Section 3, we use the theoretical specifications to study US pension plan risk using data from 1993 to 1998 for companies filing Employee Retirement Income Security Act (ERISA) form 5500. This period was prior to the sharp and sustained decline in the stock market, particularly Nasdaq, in 2000–2002, and the subsequent media spotlight on pension plan risk. We find that the market risk of the firm's equity reflects the risk level of its pension plan. In Section 4, we examine the sensitivity of test findings to our assumptions. We find our results to be robust. In Section 5, we conclude.

2. Theory

In the United States, when a company sponsors a defined-benefit pension plan, the plan's assets and liabilities, although segregated, are, in economic terms, assets and liabilities of the company. The company and its pension plan as a consolidated entity have three groups with a claim on the firm's total assets: (1) the employees–retired and active, (2) the investors–shareholders and creditors, and (3) the government, through corporate taxes and corporate pension benefit guarantees. The employees' claim on the retirement benefits, the pension liability, is a debt-like liability of the firm, secured by the pension assets as specific collateral.

Ignoring the effect of taxes and the PBGC, we derive the relations between pension plan risk and firm equity risk, and we discuss how the firm's operating asset risk can be correctly estimated from the pension plan risk and observed equity risk. We then derive the structure of estimation specification errors in measuring firm operating asset risk when pension risk is accounted for improperly. In doing so, we analyze two circumstances: (1) that the entire pension plan, assets and liabilities, is neglected in the estimation of operating asset risk and (2) that the values of pension assets and liabilities are correctly taken into account, but the risks of plan assets and liabilities are not. We then discuss the effect of corporate tax and the role of PBGC.[2]

2.1. The estimation of operating asset risk from pension and stock market data

Consider the case in which there are no taxes and no Pension Benefit Guaranty Corporation.

Define OA as the value of operating assets, E as the value of equity, D as the value of debt, PA as the value of pension assets, PL as the value of pension liabilities, $S = PA - PL$ as the pension surplus, and $L = D/E$ as the leverage ratio. By the balance sheet identity,

$$\textit{assets} = OA + PA = E + D + PL = \textit{liabilities}.$$

We examine three cases.

Correct case: The calculation of operating asset risk correctly incorporates both the value and the risk characteristic of the pension plan.

The beta of operating assets, β_{OA}, when both the pension value and pension risk are correctly taken into account is

$$\begin{aligned}\beta_{OA} &= \frac{E}{OA}\beta_E + \frac{D}{OA}\beta_D - \left[\frac{PA}{OA}\beta_{PA} - \frac{PL}{OA}\beta_{PL}\right] \\ &= \frac{E}{OA}(\beta_E + \beta_D) + \frac{D-E}{OA}\beta_D - \frac{PA}{OA}(\beta_{PA} - \beta_{PL}) - \frac{S}{OA}\beta_{PL}. \end{aligned} \tag{1}$$

Error case 1: The calculation of operating asset risk ignores the pension plan, both its value and its risk.[3]

If both the value and the risk of the pension plan are ignored, then the estimated operating asset beta becomes

$$\hat{\beta}_{OA} = \frac{D}{E+D}\beta_D + \frac{E}{E+D}\beta_E. \tag{2}$$

[2] Throughout the paper we are focusing on the pre-tax cost of capital, or, all-equity cost of capital. This is to take the firm's actual levered cost of equity and debt and to back out the cost of capital as if the firm were all-equity financed (i.e., assuming away the impact of debt interest tax shield and the cost of financial distress). The all-equity cost of capital serves as a better benchmark than the actual cost of capital, for all firms by removing the impact of financing, and thus making it much more comparable across firms that have potentially different capital structure. This would also accord better with people's intuition: when it is said that two firms in the same industry are comparable, it typically means that their assets have comparable risk. Thus the comparison is on the left-hand side of the balance sheet (i.e., assets), instead of the right-hand side of the balance sheet (i.e., financing decision).

[3] The standard textbook treatments typically calculate the weighted average cost of capital (WACC) as the weighted average cost of debt and equity, with no adjustment for pension risks. See examples cited in footnote 2.

Subtracting Eq. (1) from Eq. (2), the resulting estimation specification error, defined as $\hat{\varepsilon}_{OA} = \hat{\beta}_{OA} - \beta_{OA}$, is

$$\hat{\varepsilon}_{OA} = \frac{PA}{O\hat{A}}(\beta_{PA} - \beta_{PL}) - \frac{S}{O\hat{A}}[\beta_{OA} - \beta_{PL}], \tag{3}$$

where $O\hat{A} = OA + S$.

Proof. See Appendix.

By inspection of Eq. (3), and given that usually $\beta_{PA} \geqslant \beta_{PL}$ and $\beta_{OA} \geqslant \beta_{PL}$, the condition for $\hat{\varepsilon}_{OA} \geqslant 0$ is $S \leqslant PA(\beta_{OA} - \beta_{PL})/(\beta_{PA} - \beta_{PL})$. Therefore, as long as the pension surplus is not too large, the specification error on the estimate of the operating asset beta generally leads to a positive bias.

Error case 2: The calculation of risk includes the pension surplus, *S*, but neglects any difference between β_{PA} and β_{PB}.[4]

If the person doing the calculation assumes that pension asset and pension liability risk are the same and equal to the risk of the debt of the firm, $\hat{\hat{\beta}}_{PA} = \hat{\hat{\beta}}_{PL} = \beta_D$, then the risk of the operating assets is given by

$$\hat{\hat{\beta}}_{OA} = \beta_E \frac{E}{OA} + \beta_D \frac{(D - S)}{OA}.^5 \tag{4}$$

Thus, subtracting Eq. (1) from Eq. (4), the specification error in the estimated beta is given by

$$\hat{\hat{\varepsilon}}_{OA} = \frac{PL}{OA}(\beta_D - \beta_{PL}) + \frac{PA}{OA}(\beta_{PA} - \beta_D). \tag{5}$$

Proof. See Appendix.

In practice, the risk levels of pension liabilities and firm debt are similar for firms with normal leverage ratios, whereas the portion of pension assets that are invested in equities has significantly higher beta risk than the firm debt. Neglecting this higher pension asset risk leads to a positive bias in the estimation of the beta of the operating assets.

The biases from ignoring the pension asset risk can be substantial. The biases from counting the value of the pension plan but ignoring the risk of pension plans can also be large. In Tables 1 and 2 we underscore this point with four examples of well-known large firms.

In Table 2 we posit that the pension liability has the same beta as the firm's debt, both assumed to be 0.175. The overall beta for pension assets is assumed to be 0.59, the median level of pension asset beta in our sample.[6]

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[4]It recognizes the surplus or shortfall in pension plan value, perhaps because it appears as a net entry on the firm's balance sheet but it treats that surplus or shortfall as having the same beta as debt.

[5]Once the value of the pension plan is taken into account, some risk level has to be assigned to its assets and liabilities for the calculation of firm operating-asset risk. It is generally incorrect to assume that pension assets have the same risk as pension liabilities. If the debt of the firm is highly rated with a similar duration as the pension liabilities, it is reasonable to treat them as having the same systematic risk.

[6]Our sample ends in 1998. In more recent years, many firms have increased their pension asset allocation into equities. The PBGC recommended that pension plans invest 60–80% of the pension asset in equities, See, for example, Bodie (1996). During the bull market of the 1990s many firms did just that.

Table 1
Selected company balance sheet information for 2001
Pension asset, pension liability and market cap information are as estimated based on the global equity research report published by UBS Warburg, September 19, 2002. Book values of debt are obtained from Compustat. Figures are in millions of dollars

Company	Pension asset	Pension liability	Pension surplus (shortfall)	Market capitalization of equity	Book value of debt	Operating asset $(E+D-PA+PL)$
Boeing	33,810	32,693	1,117	30,942	12,265	42,090
Du Pont	17,923	18,769	(846)	42,593	6,814	50,253
Eastman Kodak	7,942	7,439	503	8,562	3,200	11,259
Textron	4,480	3,908	572	5,856	7,149	12,433

Table 2
Estimated equity and operating asset betas for 2001
Beta of equity are estimated using capital asset pricing model, using data on three-year monthly stock return, obtained from the Center for Research in Security Prices, and the value-weighted return on all stocks on NYSE, AMEX, Nasdaq as the proxy for market. Beta of debt is assumed, as throughout the paper, to be 0.175. Operating asset beta correct is the operation asset beta when correctly accounting for pension value and risk, Operating asset beta error 1 is the operating asset beta ignoring pension plan altogether, and Operating asset beta error 2 is the operating asset beta counting pension value but misrepresenting pension risk

Company	Equity beta	Operating asset beta correct	Operating asset beta error 1	Percent overestimate for error 1	Operating asset beta error 2	Percent overestimate for error 2
Boeing	0.689	0.228	0.543	139	0.553	143
Du Pont	0.707	0.482	0.634	32	0.626	30
Eastman Kodak	0.867	0.416	0.679	63	0.701	69
Textron	0.732	0.292	0.426	46	0.438	50

Substituting these assumed beta values into Eq. (5),

$$\hat{\varepsilon}_{OA} = (0.67 - 0.175)\frac{PA}{OA} = 0.495\frac{PA}{OA}. \tag{5'}$$

By inspection of Table 1, three of the firms' plans are overfunded and the fourth, Du Pont, has a small pension deficit. All four firms, however, have pension assets that are large relative to their market capitalization. The correct estimates of operating asset beta for these four firms are 0.23, 0.48, 0.41, and 0.29, respectively, but the flawed procedure that ignores the pension plan altogether produces estimates of operating asset betas of 0.54, 0.63, 0.68, and 0.43, respectively. The estimation errors are large, and the operating asset betas are overstated by between 32% and 139%. The last column shows that, when pension value but not pension risk is incorporated in the calculation, the resulting betas are still significantly different from their correct values.

Table 3
Estimated costs of capital for 2001
The cost of capital is estimate as the all-equity cost of capital (i.e., by ignoring the impact of tax on debt cost of capital). We use the capital asset pricing model to estimate equity cost of capital, assuming a risk-free rate of 5%/year and a market risk premium of 7%/year

Company	Correct cost of capital estimate (%)	Cost of capital estimate error 1 (%)	Percent overestimate for error 1	Cost of capital estimate error 2 (%)	Percent overestimate for error 2
Boeing	6.59	8.80	34	8.87	35
Du Pont	8.37	9.44	13	9.38	12
Eastman Kodak	7.91	9.75	23	9.91	25
Textron	7.04	7.98	13	8.06	15

Thus, standard cost of capital calculations, which do not distinguish between the operating asset risk and pension plan risks, can materially overestimate the discount rate for operating projects. For an equity risk premium of 7% and a risk-free rate of 5%, the correct cost of capital for the existing operating assets of Boeing is 6.59%, but the standard approach yields 8.80%, an overestimate of about 34%. For Du Pont, Eastman Kodak, and Textron, the correct cost of capital is 8.37%, 7.91%, and 7.04%, respectively, while the standard approach yields 9.44%, 9.75%, and 7.98%, respectively, for a 13% to 23% error. The effect of the overestimation of cost of capital is summarized in Table 3.

2.2. *Effect of corporate taxes*

Consider the effect of corporate taxes on the relation between the risk of the pension plan and the risk to investors in the firm. There is a considerable range in the theory of corporate finance about the effect of taxes on the valuation of a firm and, thus, on the risk of the firm. The original controversy is focused on whether debt financing increases the total value of the firm relative to its value under all-equity financing. As shown by Miller (1977), the answer hinges on the complex interaction between corporate and personal taxation in a general model of capital market equilibrium.

Black (1980) and Tepper (1981) examine the effect of corporate taxes on the valuation of corporate pension assets and liabilities. Under symmetric assumptions about contribution opportunities, tax payments, and rebates, they conclude that a \$1 change in the pre-tax value of pension surplus (i.e., assets minus liabilities) causes a $\$(1-t)$ change in the value of the firm, where t is the effective corporate tax rate. Thus the government bears fraction t of the pension surplus risk through taxes.

Bulow et al. (1987) revisit the question and conclude that depending on the extent to which the ceiling on pension fund contributions can be binding, the relation ranges from $(1-t)$ to 1.0. Beyond the theoretical complexities, there are further empirical ones. The effective versus statutory tax rates for real-world firms vary considerably in cross-section and for the same firm over time. Accounting rules that govern how pension surplus is computed for determining contribution limitations currently have multi-year smoothing features. Thus, in the absence of individual firm tax-rate data, we make no adjustment for taxes in our test specification in Section 3.

2.3. Effect of PBGC insurance

The PBGC covers any shortfall in funding for the pension plans of bankrupt firms, in effect providing the plan participants with a put option on the pension fund collateral for their benefits (There is a ceiling on benefits covered of $44,386 per year per employee, for the year 2004). The price charged for this PBGC insurance is not a function of either the credit quality of the plan sponsor or of the risk of the plan's assets. Thus the premium for coverage is not equal to its fair market value. Distressed firms are charged less than the fair value and healthy firms are charged more.[7] Even if PBGC insurance were fairly priced, the insurance transfers part of the risk associated with the pension assets and liabilities from the corporate sponsor to the PBGC. PBGC insurance creates an incentive for distressed firms to underfund the pension plan and invest the plan in risky assets. Bodie et al. (1985) find some empirical evidence of this effect. At the theoretical level, the existence of the PBGC introduces a complex nonlinear relation between the value and risk of pension assets and liabilities and the risk of investor capital for corporations that are in financial distress. See Bodie (1996), for the discussion about the PBGC pension put. Partly for this reason, we focus in our empirical analysis on firms that are not in distress.

3. Empirical analysis

In Section 2 we derive the risk relations among the firm's assets and liabilities when they are fully recognized by investors and measured at market prices. In this section we explore the question: Do those relations hold in practice? We consider, as an empirical matter, the extent to which a company's pension funding status and asset mix are incorporated in the risk of its equity. Specifically we test the hypothesis that a higher pension plan risk translates into a higher overall firm market risk, and we also estimate the magnitude of the pension risk-firm risk relation.

3.1. Data and measurement of variables

The data used in our study come from three sources: ERISA Form 5500 filings, Compustat, and the Center for Research in Security Prices (CRSP). ERISA Form 5500 provides asset allocation information for each plan sponsored by a company. The assets are disaggregated into categories such as certificates of deposit, US government securities, corporate debt instruments and common stocks and reported at market value. Sponsors of any plan with more than one hundred employees are required by law to file the form. The Form 5500 tape that we acquire covers the years 1993–1998. We obtain company level data about pension liabilities and other balance sheet and income statement variables from Compustat. We match data from the two sources to create a merged company level data set. CRSP data are used to calculate equity betas for the firms in our sample.

Form 5500 data are made available to the public with roughly a two-year lag.[8] Compustat data are created from company 10-K reports, which are released with a much

[7]The detailed procedures for setting pension premium can be found from the PBGC website, at http://www.pbgc.gov/publications/factshts/PREMFACT.htm.

[8]The Form 5500 data are released by ERISA with roughly a two-year lag. However, part of the pension funds asset allocation information might be available to the general public sooner, especially if these pension funds are

Table 4
Pension asset categories as reported in Form 5500 and assumed beta risk

Pension asset categories	Assumed beta	Average asset allocation (percent)
Equities		
Common stock	1.000	11.9
Joint venture	1.000	0.3
Employer securities	Estimated equity beta	6.4
Interest in registered investment companies	1.000	29.7
Preferred stock	0.175	0.2
Bonds		
Government bonds	0.175	5.1
Corporate debt instruments (preferred and other)	0.175	3.3
Loans to participants	0.175	20.3
Loans secured by mortgages, and other loans	0.175	0.3
Cash		
Non-interest bearing cash	0.006	3.7
Certificates of deposit	0.006	18.5
Real estate		
Both income producing and nonincome producing real estate	0.150	0.3

shorter time lag than Form 5500 data. The Compustat data are also more widely used by market participants.

From the asset allocation information reported in Form 5500, we compute the total amount of pension assets. We also measure the average systematic risk exposure from the pension plan assets by making certain assumptions about the beta risk of various categories of assets. Table 4 contains the assumptions about beta for various asset classes that we use in computing the total risk of pension assets and pension liabilities, as well as the average asset allocation decisions of DB plans in our sample.[9]

The total pension liability measure is obtained from COMPUSTAT. COMPUSTAT reports two different measures: the Accumulated Benefit Obligation (ABO) and the

(*footnote continued*)
large and self-managed. Funds are typically required by various other regulations to reveal certain information to the public. For example, Securities and Exchange Commission regulation 13F requires institutions (including pension funds) to report quarterly holdings of securities when the total holdings are above $100 million. In any case, the lack of timely information in pension asset allocation decisions might not be as severe a problem as it appears. Pension asset allocation decisions empirically do not change much over time for any specific firm. A simple correlation analysis reveals that the first-order auto-correlation between pension asset risk over time is more than 0.95. Thus, knowing the past asset allocation decisions of a firm generally gives one a good idea about its current asset allocation decisions.

[9]The estimates of the beta risk for asset categories are drawn from a study done by the Harvard Management Company to calculate the portfolio choices for the firm. The numbers are cited from Light (2001). We take corporate debt as the same beta as the other debt instruments, at 0.175. This is a simplification. The beta of real-world corporate debt should depend on the duration and riskiness of the debt, but we lack those data. As a robustness check, we also approximated the corporate debt beta by estimating the beta of the five-year Treasury note. The average rolling beta estimate for our sample period is 0.178, reasonably close to what we use.

Projected Benefit Obligation (PBO). We believe that the ABO is a more accurate measure of the economic value of the liability. See, for example, the discussion in Bodie 1990. However, the ABO was required to be disclosed only prior to FAS 132, and now it needs be disclosed only for underfunded plans. Therefore in our data, ABO data are sometimes missing. Whenever possible, we use the ABO as the measure of the amount of pension liability. In the cases in which such measure is not available, we estimate the ABO as the PBO multiplied by the most recently available historical ratio of ABO to PBO for that firm. If no such ratio is available, we multiply the PBO by 0.83, the average of ABO to PBO for all firms in our sample.

There is some reason to believe that pension liabilities might have a higher beta than corporate debt, because the former typically has a longer duration. While some controversy has arisen as to what is the most appropriate benchmark of pension liability, one commonly used benchmark for pricing pension liability is the 30-year Treasury bond rate.[10] In our sample period, the estimate of duration of a 30-year Treasury bond is roughly 13 years, using the average reported duration from CRSP Fixed Term Indices File. This is in line with the duration assumption used in current practice.[11] Thus we think a 30-year Treasury bond can be a useful benchmark to estimate the pension liability beta. Using that benchmark, the in-sample estimate of the beta of pension liabilities is about 0.46 if we do a 60-month rolling estimate, using all the monthly returns up to the end of the previous year. However, the estimate is sensitive to the underlying assumptions. An estimate using all 72 months of in-sample data from 1993 to 1998, for example, would come to about 0.18.[12] Both measures might have some justifications. The rolling beta probably captures what the market knows at that time, while the in-sample estimate including 1998 data might also be appealing as it shows how infrequent events could potentially impact the beta.[13] In our empirical results below, we report both estimates for the beta of pension liabilities ($\beta_{PL} = 0.18$ and $\beta_{PL} = 0.46$), and let the readers decide which one is more appropriate.

Both the measures of pension assets and pension liabilities are still subject to measurement errors. ERISA Form 5500 contains information only for pension asset classes, and an asset within the class certainly can have different systematic risk than what we assume for the average of the class. On the pension liabilities side, firms do have some leeway in calculating the pension liabilities. For example, firms are allowed to set the discount rate for pension liabilities between 90% and 120% of the 30-year Treasury rate. As mentioned before, there are cases in which the precise measures of ABO are not available and have to be approximated. These measurement errors likely add noise, but not systematic bias, to the empirical results presented below.

[10]The other commonly used benchmark is the AA-rated bonds of significant maturity. See, for example, Statement of Financial Accounting Standards No. 87: Employers' Accounting for Pensions. Other benchmarks include the 30-year swap rate (dollar LIBOR), Moody's Corporate Bond Yield Averages, and agency benchmark bonds. See, for example, Moore and Peskin (2002).

[11]According to Jared Gross, formerly chief financial economist at the PBGC, both the current law and the recent legislative proposals use a set of widely available bond indices for the purpose of creating a discount rate used in present-valuing pension liabilities. The concept at work is that these indices are generally consistent with the overall duration of pension liabilities (12 years is a reasonable approximation).

[12]Year 1998 estimate of bond beta is different from previous years. We suspect it is linked to the flight to quality around the Russian bond default and the LTCM crisis.

[13]For the same reason, many people have argued against taking out rare events such as the Depression years and the years immediately following the World War II, when estimating equity premium.

Table 5
Summary statistics

Equity beta is calculated using market model and up to one year of weekly return data. Weighted average beta for equity and debt is calculated as the market value weighted average beta of debt and equity: $\beta_E E/(E+D) + \beta_D D/(E+D)$, and Pension risk is $\beta_{PA} PA/(E+D) + \beta_{PL} PL/(E+D)$, where β_{PL} is assumed to be equal to 0.180 and β_{PA} is the weighted average beta of all pension assets

Variable	Number of observation	Mean	Standard deviation	Quatile 1	Median	Quatile 3
Equity beta	4453	0.759	0.868	0.283	0.705	1.203
Firm risk (weighted average beta for equity and debt)	4453	0.525	0.517	0.231	0.486	0.793
Pension risk (pension asset risk minus pension liability risk)	4453	0.014	0.074	−0.012	0.003	0.036

To estimate the equity betas, we use weekly data for one year (up to 52 observations). To make sure our beta estimate is meaningful, we eliminate stocks that have not been traded for more than 43 weeks during a year. Because we are using relatively higher frequency data, to adjust for nonsynchronous trading, we employ the Dimson (1979) adjustment with one lag and no leads to calculate the beta. To test robustness, we also examine different specifications of leads and lags and do not find a qualitative change in the results.

The summary statistics of our sample is reported in Table 5.

Table 5 shows a large variation in the pension asset betas. Further analysis shows that the pension asset beta variation is largely cross-sectional, such that each year we have a standard deviation of 0.3–0.4 for the cross-sectional variation of beta of pension assets. However, for any specific firm, the pension asset beta changes only slowly over time, such that the pension asset beta for the sample firm is highly correlated over time.

From the firm's balance sheet identity, $E + D = OA + PA - PL$, the firm's invested capital, defined as debt plus equity, equals the value of operating assets plus the pension plan surplus.

Define the capital structure risk, i.e., the systematic risk borne by the equity and debt holders of the firm, as

$$\beta_{E+D} = \beta_E \frac{E}{E+D} + \beta_D \frac{D}{E+D}.$$

It follows that

$$\beta_{E+D} = \frac{\beta_{PA} PA}{E+D} - \frac{\beta_{PL} PL}{E+D} + \frac{\beta_{OA} OA}{E+D}.$$

Thus there is a one-to-one relation between the risk of the firm's capital structure, measured by the weighted average of equity and debt risk, and the net pension plan risk, measured as

$$\beta_{\text{Pension}} = \frac{\beta_{PA} PA}{E+D} - \frac{\beta_{PL} PL}{E+D}.$$

Namely,

$$\beta_{E+D} = \beta_{\text{pension}} + \frac{\beta_{OA} OA}{E + D}. \tag{6}$$

We use this relation to test whether the beta risk of pensions is incorporated in the risk of the firm's capital structure

$$\beta_{E+D} = a + b\beta_{\text{pension}} + \varepsilon. \tag{7}$$

In this regression, b represents the sensitivity of firm risk to firm pension risk, and a represents the part of the expected firm risk that cannot be picked up by the pension risk. We try to capture a by various instrumental variables. We expect b to be positive and close to one in magnitude.

By using a single coefficient b in the above regression, we are assuming that the degree of sensitivity of firm risk to pension asset risk and pension liability risk is the same. While one might attempt to further distinguish the hypothesis between the pension asset and pension liability risk sensitivity, estimation error for the beta of pension liability makes the interpretation of such a refinement in the test questionable. Beta of pension liability estimate varies, depending on the estimation method. Adding to the complication, disagreements could arise about the true benchmark with which to compare pension liability, and large cross-sectional variation could be found in individual pension plan liability duration, which we do not observe. Such variation could be influenced by a variety of characters of the plans: age of the retiree and current employees, accumulated benefit, etc. Therefore, compared with the precision of the pension asset beta estimate, pension liability beta estimates are much noisier. This noise causes a large standard deviation and sensitivity of the point estimates to assumptions about pension liability beta. As a consequence, we report in each table the corresponding results for two different values of the β of pension liability: $\beta_{PL} = 0.18$ and $\beta_{PL} = 0.46$.[14] Given the noise, we emphasize less the precise magnitudes of the point estimates, as they typically span a large confidence interval. Also for that reason, we focus our discussion on the regressions with single coefficient for pension risk, instead of separately estimating the impacts of pension asset and liability risk on firm risk. However, as a robustness check, we also report the regression results allowing for separate estimation of the impacts of pension asset and liability risk on firm risk.

3.2. Restriction to nondistressed firms

As noted before we restrict our attention to firms that are not in financial distress. Firms in financial distress should be analyzed separately for three important theoretical reasons. First, for distressed firms, the effect of the guarantee provided by the Pension Benefit Guarantee Corporation is potentially large and must be taken into account. Second, the betas of the debt and equity of firms in distress are nonlinear functions of the value of the firm. See Merton (1992, Chapters 11, 12). Third, we use the book value of debt as an approximation for market value. This proxy works reasonably well when the firm is not in distress, because the market value of the debt typically does not deviate significantly from

[14] We do also report the regression coefficient for a whole range of the assumption of the beta of pension liability in Fig. 1.

the book value of debt.[15] But this is not true for debt of firms in financial distress, which can sell at a discount to book value and often trades with an equity-like beta. In fact, when we examine the distressed firms, we do not obtain any reliable relation between pension risk and firm risk.

We use three empirical measures to identify the financially distressed firms: (1) book to market value as a combination measure of both types of distress, in which a higher measure indicates distress, (2) return on investment as a measure of operating business distress, in which a lower measure indicates distress, and (3) leverage as a measure of financial distress, in which a higher measure indicates distress.[16,17] In each year in our sample, we rank all firms in the previous year by each measure of distress, and take the decile of firms with the most severe measure as distressed and the rest as nondistressed. We subsequently run regressions for the next year only on firms that are not in distress in the previous year.

3.3. Test results and interpretation

We fit the following panel data regression:

$$\beta_{E+D} = a + b\beta_{\text{pension}} + \varepsilon. \quad (8)$$

To be consistent with a large body of literature in finance, we use the Fama and MacBeth (1973) methodology to compute robust standard errors for the coefficient estimates. Specifically, we first run cross-sectional regressions for each year separately, while controlling for fixed effects at the industry levels using the two-digit Standard Industrial Classification (SIC) code, and report the time-series averages of the coefficient estimates and use the time-series standard errors of the average slopes to draw inferences. The Fama and MacBeth methodology is a convenient and conservative way to account for potential cross-correlations in the residuals. As reported by Fama and French (2002), the Fama and MacBeth standard errors are often two to five times the Ordinary Least Squares standard errors from pooled panel data regressions that ignore residual cross-correlations.

The Fama and MacBeth procedure does not take into account autocorrelations, thus it is further corrected by following the procedure in Pontiff (1996) to adjust the time-series standard deviations to allow for autocorrelations in the coefficient estimates.[18]

[15] A caveat is that even for non-distressed firms, interest rate changes can cause significant changes in the value of fixed rate debt value. The 0.175 estimate for the beta of debt used throughout the paper is primarily the result of estimated correlations between interest rate changes and equity returns during the sample period and not the risk of default. With the widespread use of interest rate swaps by corporations, it is not easy to determine the effect of interest-rate changes on firm and equity values. We have nevertheless explored this effect and tried to adjust the book value of debt by the change in the market interest rate to better approximate the market value of debt. Such adjustments give results that are consistent with those reported in the paper, suggesting that the adjustment for book to market value difference in debt is not driving the results of the paper. Detailed results are available upon request.

[16] We recognize that for the Fama and French (1992) model, book-to-market is a systematic risk factor, not necessarily associated only with distress. As discussed in Section 4.1, excluding or including this group in the firm sample does not affect our findings.

[17] Return on investment is defined as net income divided by total assets, and financial leverage is defined as debt divided by total assets, both are defined explicitly in Table 7. Book-to-market ratio is the book value of common equity plus balance-sheet deferred taxes for fiscal year $t-1$, over market equity for December of year $t-1$. Use of these measures as indicators for financial and operating-business distress can be found in Andrade and Kaplan (1998).

[18] Pontiff (1996) realizes that, in a setting of serious serial correlation, because the slope coefficients in the Fama and MacBeth regressions are persistent through time, the Fama and MacBeth standard errors could still be biased

Table 6
Relation between pension risk and firm risk: simple test

This table reports regression results using Employee Retirement Income Security Act Form 5500 filing data from 1993 to 1998. The regression being run is: $\beta_{E+D} = a + b\beta_{\text{pension}} + \varepsilon$. All results are estimated with company betas estimated using market model with one lagged term and with the end-of-year pension data. The regression is run for each year, controlling for fixed effect at the industry level, then the time-series mean and standard deviation of the regression coefficients are used to make inferences. The standard deviation, reported under each coefficient and in paranthesis, is further adjusted for potential time-series correlation

Measure of distress	Book-market ratio		Return on investments		Financial leverage	
	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$
Intercept	0.76	0.80	0.76	0.80	0.77	0.80
	(0.45)	(0.45)	(0.44)	(0.44)	(0.44)	(0.44)
Pension risk	1.51	0.82	1.50	0.83	1.33	0.79
	(0.34)	(0.15)	(0.33)	(0.15)	(0.31)	(0.14)
Number of observations	4008	4008	4008	4008	4008	4008
R-squared	0.1852	0.1875	0.1869	0.1832	0.1812	0.1857

The regression coefficients and their *t*-statistics are reported in Table 6. The results indicate a positive relation between pension plan risk and firm risk. One unit of pension risk increases the firm risk by 1.33–1.51 units if the assumed pension liability beta is 0.18; 0.79–0.83 units if the assumed pension liability beta is 0.46. The relation is statistically different from zero.

Consider now the implicit assumption underlying the relation between the beta of the firm debt plus equity and the beta of its pension assets as specified in Eq. (8). By inspection of Eq. (6), (6′) firm beta is affected by pension risk. The regression specification in Eq. (8) gives an unbiased estimate of the impact of pension risk only if the omitted variable, operating asset risk, is uncorrelated with the pension asset and liability risk. Such an assumption is clearly unfounded. Much of the risk in the pension fund comes from its equity holdings and firm human resource policy, and these are potentially highly correlated with the firm's own operating asset risk. As another, more subtle source of correlation, some firm managements could take an integrated perspective in managing their firms' pension and operating asset risk, causing pension and nonpension risk to potentially be correlated.

We do not have a direct measure of the nonpension operating asset risk and so, in an expanded specification, we substitute control variables as proxies for differences in the nonpension operating asset risks across the firms. To make sure that we control as much as possible for other factors that might potentially explain the operating asset risk, we do an extensive search for factors identified by the previous literature as relevant in the study of firm systematic risk. In particular, Bughin (1995) advocates the importance of market shares in explaining the firm's product market power, therefore systematic risk level; Gombola and Ketz (1983) and Young et al. (1991) argue that capital intensiveness, cash

(*footnote continued*)
downward. He proposes correcting for such bias by regression the time-series of the parameter estimates on an intercept term and modeling the residuals as an autoregressive process. As we have six years of data, we model the residuals as an AR(1). Changing the specification to AR(2) does not qualitatively affect the results in the paper.

Table 7
List of control variables

Variable	Calculation	Compustat item numbers
Market share by value	Calculated using market value and the industry classification codes	DATA24*DATA25
Market share by sales	Calculated using total sales and the industry classification codes	DATA12
Capital intensiveness	Current assets/total assets	DATA4/DATA6
Cash position	Cash and short-term investments/total assets	DATA1/DATA6
Financial leverage	Debt/total assets	(Data9 + Data34)/DATA6
Growth rate	Log (total assets/lagged total assets)	Log(DATA6/DATA6_lag)
Liquidity	Current assets/current liabilities	DATA4/DATA5
Return on investment	Net income/total assets	DATA172 / DATA6
Firm size	Log (total assets)	Log(DATA6)
Research and development	Research and development expense/ total assets	DATA46/DATA6
Advertisement	Advertising expense/total assets	DATA45/DATA6

position, and return on investment could potentially explain firm beta; Rosenberg and McKibben (1973) and Rosett (2001), among others, point out that financial leverage could affect firm risk level; Beaver et al. (1970) and Young et al. (1991) propose the use of growth rate of the firm assets and the liquidity of firms; Beaver et al. (1970), Rosenberg and McKibben (1973), and Reinganum (1982) argue for the importance of firm size in explaining firm beta; and Chan et al. (2001) argue that research and development and advertisement affect stock returns systematically and therefore should be part of the firm systematic risk. By using these variables in an expanded specification, we can also see if our significant findings in the univariate analysis of pension fund risk recognition by the market in Eq. (8) are just a surrogate for the variables that were used in earlier studies to test whether pension plan value is recognized in a firm's stock price. That is not the case.

The list of control variables and the detailed procedure to construct them is in Table 7.

The results of the regression with control variables are listed in Table 8, which reports explicitly only the coefficient estimates and their significance for the pension plan risk variables as in Eq. (8). We also report the estimates of coefficients for all control variables.

The coefficient on pension risk is slightly different, but still statistically significant. The point estimate of the coefficient ranges from 0.85 when the assumed $\beta_{\text{pension\_liability}}$ is 0.18 to 1.22 when the assumed $\beta_{\text{pension\_liability}}$ is 0.46. This is not significantly higher than one minus the corporate tax rate.[19]

[19]The reason for a regression coefficient to be higher than one minus the tax rate could be the fact that many firms are overfunded during the 1993–1998 period, thus according to the discussion in Bulow et al. (1987) their funding constraint is binding. Burlow, Morck, and Summers argued that, if the pension plan reached funding ceiling and the firm is otherwise unable to contribute further to the pension plan, and if that increase in the pension asset value (through appreciation of market value of pension assets) is never forced to be taken out, so that the plan could be overfunded forever, then, for each dollar increase in plan asset value, the firm value increases by \$1. To see this, assume the tax rate is t, and firm pre-tax investment return is r. Then, for a \$1 increase in the market value of pension assets, $(1-t)$ of firm value is created immediately because pension assets are pre-tax and can be converted to firm asset at the rate of $(1-t)$. Also, because the \$1 in the pension plan earns returns of \$$r$

Table 8
Relation between pension risk and firm risk, nondistressed firms only

This table reports regression results using Employee Retirement Income Security Act (ERISA) Form 5500 filing data from 1993 to 1998. The regression being run is $\beta_{E+D} = a + b\beta_{\text{pension}} + c\text{control} + \varepsilon$. All results are estimated with company betas estimated using market model with one lagged term and with the end-of-year pension data. The regression is run for each year, controlling for fixed effect at the industry level, then the time-series mean and standard deviation of the regression coefficients are used to make inferences. The standard deviation, reported under each coefficient and in paranthesis, is further adjusted for potential time-series correlation

Measure of distress	Book–market ratio		Return on investments		Financial leverage	
	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$
Intercept	−0.04	−0.02	−0.37	−0.34	0.11	0.13
	(0.44)	(0.44)	(0.42)	(0.42)	(0.43)	(0.43)
Pension risk	1.22	0.85	1.12	0.88	1.12	0.84
	(0.22)	(0.13)	(0.21)	(0.12)	(0.21)	(0.13)
Market share by value	10.64	10.67	7.92	7.85	10.17	10.14
	(1.03)	(1.03)	(1.02)	(1.02)	(1.00)	(0.99)
Market share by sales	−9.65	−9.60	−6.68	−6.45	−8.50	−8.38
	(1.33)	(1.33)	(1.30)	(1.30)	(1.23)	(1.23)
Capital intensiveness	0.38	0.42	0.25	0.28	0.35	0.38
	(0.15)	(0.14)	(0.14)	(0.14)	(0.15)	(0.15)
Cash position	0.32	0.30	−0.22	−0.24	0.19	0.17
	(0.24)	(0.23)	(0.22)	(0.22)	(0.23)	(0.23)
Financial leverage	−0.01	−0.02	−0.08	−0.10	−0.46	−0.48
	(0.10)	(0.10)	(0.10)	(0.10)	(0.13)	(0.13)
Growth rate	−0.09	−0.13	0.18	0.14	0.12	0.09
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Liquidity	−0.03	−0.04	−0.01	−0.01	−0.03	−0.04
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Return on investment	2.70	2.74	7.00	7.07	2.66	2.68
	(0.23)	(0.23)	(0.34)	(0.34)	(0.21)	(0.21)
Firm size	0.08	0.08	0.10	0.10	0.09	0.09
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Advertisement	0.75	0.74	1.10	1.10	1.10	1.09
	(0.46)	(0.46)	(0.45)	(0.44)	(0.50)	(0.50)
Research and development	6.78	6.94	6.35	6.46	7.01	7.14
	(0.65)	(0.64)	(0.66)	(0.66)	(0.64)	(0.64)
Number of observations	4008	4008	4008	4008	4008	4008
R-squared	0.3762	0.3785	0.3132	0.3155	0.3657	0.3689

(*footnote continued*)
each year forever instead of $r(1-t)$ as nonpension assets would earn, there is an annual incremental value of $\$rt$. The after-tax value to the firm of this extra saving is $\$rt(1-t)$ each period. This, discounted at the after-tax rate of return of $r(1-t)$, would give a present value of $\$t$. Thus the total value to firm would be $\$(1-t)+\$t=\$1$. The

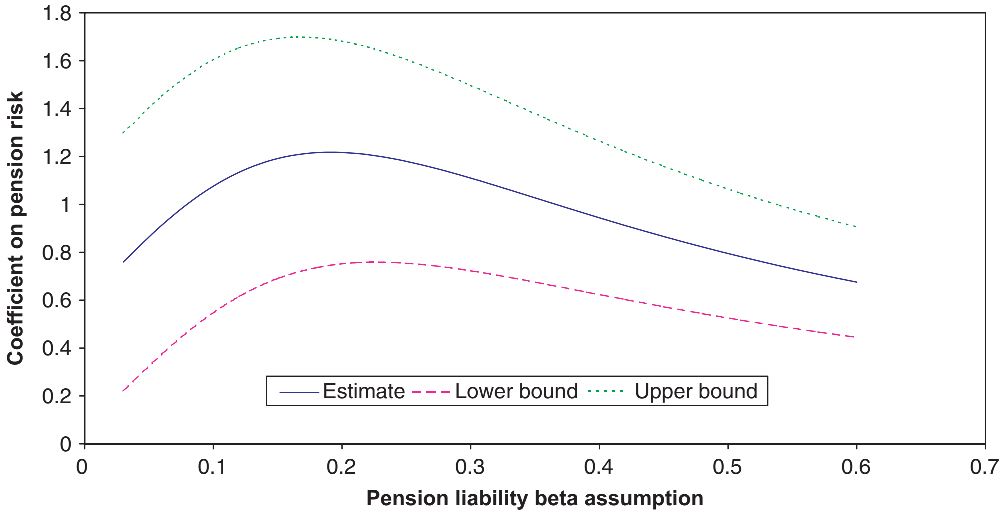

Fig. 1. Point estimate of pension risk as a function of the assumption about pension liability beta.

Pension liability beta assumptions can have significant impacts on the estimated coefficient on pension risk. Fig. 1 reports the estimated coefficient on pension risk as a function of the assumed $\beta_{\text{pension\_liability}}$. When $\beta_{\text{pension\_liability}}$ is increased from 0 to about 0.6, the coefficient estimate of pension risk first increases and then decreases. The peak coefficient estimate of 1.22 is achieved at around $\beta_{\text{pension\_liability}} = 0.2$. The coefficient estimate corresponding to $\beta_{\text{pension\_liability}} = 0.6$ is about 0.68, whereas the coefficient estimate corresponding to $\beta_{\text{pension\_liability}} = 0.03$ is about 0.76.

4. Robustness checks

In this section, we conduct several robustness checks and report the results.

4.1. Distressed firms

Distressed firms are likely to have a distinctly different pattern than nondistressed firms. Thus we re-run the regression analysis specified in Table 8 with the distressed firms subsample. The results are reported in Table 9.

Inspection of Table 9 shows that the relation between pension risk and firm risk is insignificant for these firms.

(*footnote continued*)
above is an extreme case for real-world pension plans. In practice, pension accounting rules typically allows for smoothing of pension investment gains or losses only over a limited period of time (often 15 years), but probably not infinitely. The time value of a pension asset appreciation that is slowly amortized over time has less than one-for-one relation to firm value. Using a marginal tax rate of 46% and assuming 15-year amortization, Bulow et al. (1987) calculate that the true value of a dollar change in pension asset to firm is approximately \$0.72, higher than the \$0.54 implied by $(1-t)$, but lower than \$1. The marginal tax rate for 1993–1998 is 34% to 35%, and the corresponding value of a dollar increase in pension value to firm value would be about \$0.80.

Table 9
Relation between pension risk and firm risk, distressed firm only

This table reports regression results using Employee Retirement Income Securities Act Form 5500 filing data from 1993 to 1998. The regression being run is $\beta_{E+D} = a + b\beta_{\text{pension}} + c\text{control} + \varepsilon$. All results are estimated with company betas estimated using market model with one lagged term and with the end-of-year pension data. The regression is run for each year, controlling for fixed effect at the industry level, then the time-series mean and standard deviation of the regression coefficients are used to make inferences. The standard deviation, reported under each coefficient and in paranthesis, is further adjusted for potential time-series correlation

Measure of distress	Book–market ratio		Return on investments		Financial leverage	
	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$
Intercept	0.09	0.10	0.12	0.12	−0.09	−0.10
	(0.26)	(0.26)	(0.47)	(0.48)	(0.51)	(0.51)
Pension risk	−0.29	−0.11	−0.25	−0.11	0.01	−0.08
	(0.15)	(0.09)	(0.41)	(0.26)	(0.58)	(0.32)
Market share by value	1.70	1.73	3.07	3.10	8.04	7.91
	(2.50)	(2.51)	(2.34)	(2.34)	(2.81)	(2.82)
Market share by sales	0.75	0.74	−2.98	−2.96	−5.63	−5.52
	(1.58)	(1.59)	(1.90)	(1.91)	(3.88)	(3.89)
Capital intensiveness	0.09	0.07	−0.20	−0.22	0.43	0.43
	(0.13)	(0.13)	(0.30)	(0.29)	(0.33)	(0.33)
Cash position	0.38	0.36	0.80	0.81	−1.83	−1.87
	(0.20)	(0.21)	(0.60)	(0.60)	(0.83)	(0.83)
Financial leverage	−0.03	−0.03	0.11	0.11	0.19	0.19
	(0.10)	(0.10)	(0.18)	(0.18)	(0.23)	(0.23)
Growth rate	0.04	0.04	−0.06	−0.06	−0.21	−0.20
	(0.06)	(0.06)	(0.15)	(0.15)	(0.14)	(0.14)
Liquidity	−0.01	−0.01	−0.03	−0.03	−0.08	−0.08
	(0.01)	(0.01)	(0.04)	(0.04)	(0.07)	(0.07)
Return on investment	0.00	0.00	0.05	0.05	0.71	0.72
	(0.08)	(0.08)	(0.22)	(0.22)	(0.31)	(0.31)
Firm size	0.00	0.00	0.03	0.03	−0.01	−0.01
	(0.01)	(0.01)	(0.03)	(0.03)	(0.04)	(0.04)
Advertisement	−0.90	−0.90	−1.35	−1.35	−0.94	−0.95
	(0.68)	(0.68)	(1.16)	(1.16)	(0.82)	(0.82)
Research and development	0.60	0.53	5.66	5.60	6.67	6.75
	(1.05)	(1.06)	(1.10)	(1.10)	(1.87)	(1.84)
Number of observations	445	445	445	445	445	445
R-squared	0.5125	0.5231	0.5523	0.5378	0.5227	0.5183

We also re-run the regressions of Table 8, with the full sample (both distressed and nondistressed firms). While not reported for brevity, the results are qualitatively similar to those in Table 8. The relation between pension risk and firm risk is still significant and in the predicted directions. Thus, the a priori choice to exclude distressed firms does not change the core findings.

4.2. Eliminate the impact of employer security

Many firms in our sample have employer securities in the pension assets. In the preceding tables we estimate the beta for these stocks and use these to estimate the pension asset beta. Thus, in the regression specification in Eq. (8), both sides could be affected by the firm's equity beta. It is conceivable that an estimation error in firm equity beta would therefore affect both the dependent variable and the independent variable and thus could create potential bias.

To address that concern, we conduct a robustness check in which we remove the impact of employer securities from the right-hand side, by subtracting from both sides of Eq. (8) the term

$$\beta_{\text{employer\_stock}} \bullet \frac{\$_{\text{employer\_stock\_}\textit{in}\text{\_pension}}}{E+D}$$

and re-run the regression in Table 8. The results from this robustness check are reported in Table 10.

As can be seen from Table 10, the adjustment on employer security beta does not significantly affect the results.

As another robustness check, we estimate Eq. (8) by assuming that employer security has a beta of one instead of the estimated equity beta for the firm. The results, unreported because of space considerations, do not qualitatively differ from those in Table 8.

4.3. Filtered tests

One concern with the interpretation of our findings is that there are likely to be many firms that have negligible pension assets and liabilities compared with the firm assets. For these firms, we would expect that pension risk would not have a first-order impact on the overall firm risk, especially considering the various other factors that might affect the firm risk. Including these observations in our regression analysis would not likely add information, and thus dilute the fit of the true relation we are attempting to estimate. With this in mind, we also run regressions requiring either that pension assets represent greater than a certain percentage of the total firm book asset ($PA/(E+D) > \textit{threshold}$) or that the product of pension asset beta risk and the ratio of pension asset to total asset is greater than a specified threshold ($\beta_{PA}PA/(E+D) > \textit{threshold}$). We use threshold levels ranging from 2% to 20%, and the results are qualitatively the same.

Table 11 reports the filtered test results for a 2% threshold with nondistressed firms selected by book-to-market ratio only. Other measures of distress give qualitatively similar results.

Again, our test results support the hypothesis that market seems to react to the risk level of the pension plan as predicted. A higher pension risk increases the total market risk of the firm asset, while a lower pension risk decreases the market risk of the firms.

4.4. Separate coefficient estimate of pension asset and pension liability risk

Even though we believe it to be less interpretable given the large noise in the estimation of pension liability beta, for completeness of our results we also re-run the regression with

Table 10
Robustness check with impact of employer security removed from pension risk

This table reports regression results using Employee Retirement INcome Securities Act Form 5500 filing data from 1993 to 1998. The regression being run is $\beta_{E+D} = a + b\beta_{\text{pension}} + c\text{control} + \varepsilon$, where we remove the impact of employer security from both β_{E+D} and $c\beta_{\text{pension}}$. All results are estimated with company betas estimated using market model with one lagged term and with the end-of-year pension data. The regression is run for each year, controlling for fixed effect at the industry level, then the time-series mean and standard deviation of the regression coefficients are used to make inferences. The standard deviation, reported under each coefficient and in paranthesis, is further adjusted for potential time-series correlation

Measure of distress	Book–market ratio		Return on investments		Financial leverage	
	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$
Intercept	−0.03	−0.03	−0.35	−0.35	0.12	0.12
	(0.45)	(0.45)	(0.43)	(0.43)	(0.44)	(0.44)
Pension risk	1.17	0.86	1.07	0.88	1.08	0.85
	(0.23)	(0.14)	(0.21)	(0.13)	(0.21)	(0.13)
Market share by value	10.71	10.72	8.06	7.98	10.23	10.19
	(1.05)	(1.05)	(1.04)	(1.04)	(1.01)	(1.01)
Market share by sales	−9.71	−9.64	−6.81	−6.57	−8.53	−8.41
	(1.36)	(1.35)	(1.33)	(1.33)	(1.25)	(1.25)
Capital intensiveness	0.36	0.40	0.23	0.26	0.33	0.35
	(0.15)	(0.15)	(0.14)	(0.14)	(0.15)	(0.15)
Cash position	0.29	0.28	−0.23	−0.24	0.17	0.16
	(0.24)	(0.24)	(0.23)	(0.23)	(0.23)	(0.23)
Financial leverage	−0.01	−0.02	−0.08	−0.10	−0.45	−0.47
	(0.10)	(0.10)	(0.10)	(0.10)	(0.14)	(0.14)
Growth rate	−0.10	−0.13	0.16	0.13	0.11	0.07
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Liquidity	−0.03	−0.03	−0.01	−0.01	−0.03	−0.04
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Return on investment	2.63	2.66	6.82	6.89	2.59	2.60
	(0.24)	(0.24)	(0.35)	(0.35)	(0.22)	(0.22)
Firm size	0.08	0.08	0.10	0.10	0.09	0.09
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Advertisement	0.77	0.75	1.11	1.10	1.12	1.11
	(0.47)	(0.46)	(0.45)	(0.45)	(0.51)	(0.50)
Research and development	6.67	6.82	6.24	6.34	6.89	7.01
	(0.66)	(0.65)	(0.68)	(0.67)	(0.65)	(0.65)
Number of observations	4008	4008	4008	4008	4008	4008
R-squared	0.3137	0.3155	0.3693	0.3630	0.3752	0.3726

full control variables as in Table 8, while allowing for the pension asset risk and pension liability risk to have separate impacts on firm risk. The coefficient on pension asset risk in this regression is not dependent on the assumption about pension liability beta. The

Table 11
Filtered test results

This table reports regression results using Employee Retirement Income Securities Act Form 5500 filing data from 1993 to 1998. The regression run is $\beta_{E+D} = a + b\beta_{\text{pension}} + c\text{control} + \varepsilon$. All results are estimated with company betas estimated using market model with one lagged term and with the end-of-year pension data. The regression is run for each year, controlling for fixed effect at the industry level, then the time-series mean and standard deviation of the regression coefficients are used to make inferences. The standard deviation, reported under each coefficient and in paranthesis, is further adjusted for potential time-series correlation

Filter used	Measure of distress: book–market ratio			
	$\beta^*_{PA}PA/TA > 0.02$		$PA/TA > 0.02$	
	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$	$\beta_{PL} = 0.18$	$\beta_{PL} = 0.46$
Intercept	−0.36 (0.66)	−0.33 (0.66)	−0.24 (0.52)	−0.23 (0.52)
Pension risk	1.65 (0.37)	1.24 (0.24)	1.32 (0.24)	0.98 (0.15)
Market share by value	11.34 (1.81)	11.33 (1.81)	11.59 (1.26)	11.59 (1.25)
Market share by sales	−8.14 (2.40)	−8.12 (2.39)	−10.79 (1.63)	−10.71 (1.63)
Capital intensiveness	0.28 (0.25)	0.36 (0.25)	0.24 (0.17)	0.29 (0.17)
Cash position	1.01 (0.41)	0.97 (0.41)	0.68 (0.29)	0.66 (0.29)
Financial leverage	0.25 (0.17)	0.24 (0.17)	0.03 (0.11)	0.02 (0.11)
Growth rate	−0.10 (0.14)	−0.18 (0.14)	−0.07 (0.10)	−0.11 (0.10)
Liquidity	−0.06 (0.03)	−0.06 (0.03)	−0.04 (0.02)	−0.04 (0.02)
Return on investment	3.49 (0.38)	3.53 (0.38)	2.70 (0.27)	2.71 (0.27)
Firm size	0.08 (0.02)	0.08 (0.02)	0.08 (0.02)	0.08 (0.02)
Advertisement	−0.54 (0.84)	−0.61 (0.84)	0.38 (0.53)	0.33 (0.53)
Research and development	6.50 (1.00)	6.39 (0.99)	6.65 (0.74)	6.74 (0.73)
Number of observations	1508	1508	3136	3136
R-squared	0.4148	0.4216	0.3583	0.3632

coefficient has a point estimate of 0.85 and a standard deviation of 0.25. However, the point estimate of the coefficient on pension liability risk varies considerably with the assumption about pension liability beta. Fig. 2 plots the point estimate as well as a 95%

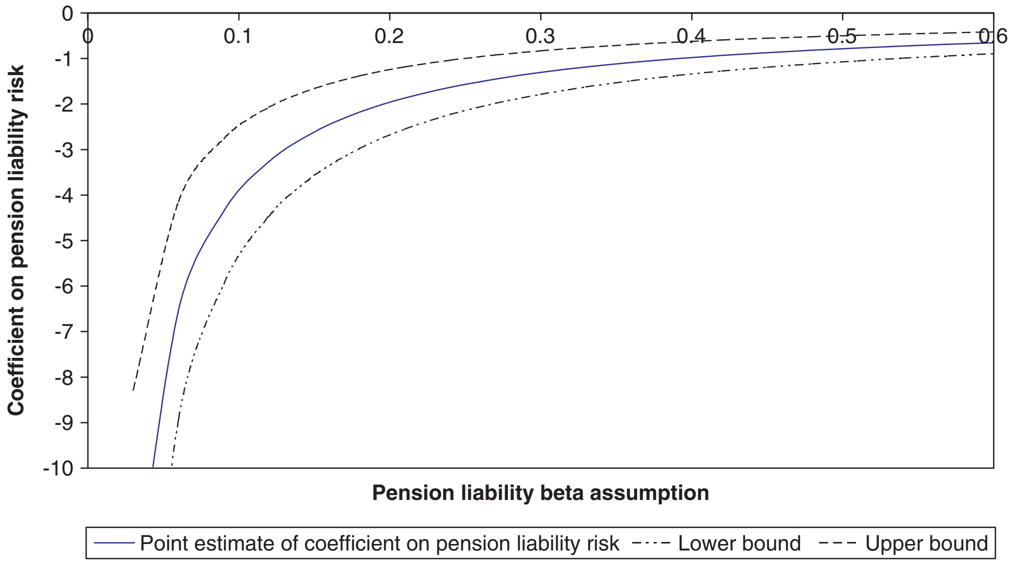

Fig. 2. Point estimate of pension liability risk in separate coefficient regression as a function of the assumption of pension liability beta.

confidence interval of the coefficient of pension liability risk, as a function of the assumed pension liability beta. For example, if pension liability beta is 0.03, the point estimate of the coefficient on pension liability risk is −13, with a 95% confidence interval of (−18, −8). However, when pension liability beta is 0.6, the point estimate of the coefficient on pension liability risk is −0.7, with a 95% confidence interval of (−0.9, −0.4).

5. Conclusion

This paper focuses on an important but previously neglected area of corporate finance. Namely, the impact of off-balance sheet and nonoperating risks on the risk of a firm's equity and the bias it could induce in estimation of the firm's cost of capital for capital budgeting. The paper's specific focus is a corporation's defined-benefit pension plan, which for some firms is as large as the market capitalization of the firm sponsoring the plan. Current accounting rules for corporate pensions are complicated and opaque. We examine the potential biases that can be introduced in the market's perception of a company's equity risk by ignoring the risk of its pension assets and liabilities, and we perform empirical tests to determine whether such a bias exists in practice.

The central empirical finding of the paper is that the stock market seems to process the available pension information without bias despite the practical difficulties of deciphering corporate pension accounts. Using the best publicly available US data, our regression tests indicate that equity betas of firms do appear to accurately reflect the betas of their pension assets and liabilities. That is good news for market efficiency of the capital markets.

The bad news is that standard cost-of-capital calculations used in corporate finance, which do not distinguish between the operating asset risk and pension plan risk, can greatly overestimate the discount rate for net present value analysis of operating projects. When calculating a firm's operating cost of capital for use in performance measurement and in capital budgeting, the standard approach to estimation fails to take proper account of the pension plan sponsored by the firm. The resulting estimate of operating asset beta and cost of capital are almost always too high. As shown in Table 3, for some well-known companies, the calculated cost of capital can be more than 30% higher than its true value. In such cases, capital projects with positive net present value could be rejected by management.

In this paper, we focus on just one nonoperating risk item of the firm, the company pension plan. Other nonoperating asset-related risk exposures might have a significant impact on the risk of a firm's equity and on the calculation of its cost of capital. A perhaps prosaic, but important, one, especially for established hi-tech firms, is the net cash and marketable securities held by the firm. Off-balance sheet risks of the firm from derivatives and other significant contractual obligations including performance guarantees can potentially distort cost of capital estimates for its operating businesses. Empirical research on their actual impact remains a task for the future.

Appendix A. Issues with the data

Despite the amount of different data files that were eventually incorporated, homogeneity exists among the data sources. The pension liabilities data all came from Compustat. The information is released to the general public through company 10 K form, thus market should be able to incorporate this information rapidly.

Following the convention in the empirical finance literature, missing research and development and advertisement measures are treated as zeros to retain the size of the valid sample. Alternatively, we test the specifications with and without research and development, advertisement, or both, and they do not affect the results qualitatively.

We combine the CRSP returns data and the Compustat data through the merged Compustat and CRSP database file, by merging PERMNO and GVKEY (the unique identifiers in CRSP and Compustat, respectively). The pension asset data from Form 5500 is matched with the Compustat through the employment identification number (EIN). This proved better than Committee on Uniform Securities Identification Procedures (CUSIP), as there are a number of redundant CUSIPs. A test of the first 100 data points showed that there was remarkably high success rate in the combination (no incorrect matches, although a handful of companies had merged and had different names in one data set or the other). The only problem is that this method works to the extent that firms have a unique EIN. Often, but not always, when a firm is purchased by another plan, the acquired firms keep its old EIN as all the employment taxes are filed by the subsidiary. Thus larger firms and more acquisitive firms present a problem. To our knowledge, the only way to partially address this is to manually search the names of the sponsors, and this works only if it is not an unrelated name of a subsidiary.[20]

The beta of pension asset is calculated by assigning different asset types to broad categories (real estate, cash, bonds, equities, etc.), and assigning beta for each asset types. If a company has more than one defined-benefit pension plan, the assets in the multiple plans are summed up. Given that we do not know the exact holdings of the pension assets

[20]We thank Mitchell Petersen for sharing with us his experience on merging pension data with Compustat data.

beyond the designation of asset classes, we are able to use only the average risk level for each asset class to measure the pension plan risk. Admittedly, if we could get more accurate estimate of the holdings of pension assets or more precise measures of each of the assets' beta, or both, that would likely improve our test results.

Appendix B. Derivation of equations in Section 2

Proof of Eq. (3). If both the value and the risk of pension are ignored, then the estimated operating asset risk becomes

$$\hat{\beta}_{OA} = \frac{D}{E+D}\beta_D + \frac{E}{E+D}\beta_E. \tag{9}$$

If $\hat{O}A = E + D$ is defined as the pseudo operating asset, then, from accounting identity, $\hat{O}A = OA + S$ and

$$\hat{\beta}_{OA} = \frac{D}{\hat{O}A}\beta_D + \frac{E}{\hat{O}A}\beta_E = \frac{1}{1+L}\beta_E + \frac{1}{1+L}\beta_D. \tag{10}$$

Thus

$$\begin{aligned}\beta_{OA} &= \frac{E}{OA}\beta_E + \frac{D}{OA}\beta_D - \left[\frac{PA}{OA}\beta_{PA} - \frac{PL}{OA}\beta_{PL}\right]\\ &= \frac{OA+S}{OA}\hat{\beta}_{OA} - \frac{PA}{OA}(\beta_{PA} - \beta_{PL}) - \frac{\beta_{PL}}{OA}S\\ &= \hat{\beta}_{OA} + \frac{S}{OA}(\hat{\beta}_{OA} - \beta_{PL}) - \frac{PA}{OA}(\beta_{PA} - \beta_{PL}).\end{aligned} \tag{11}$$

The estimation error, defined as $\hat{\varepsilon}_{OA} = \hat{\beta}_{OA} - \beta_{OA}$, is given by

$$\begin{aligned}\hat{\varepsilon}_{OA} &= \hat{\beta}_{OA} - \beta_{OA}\\ &= -\frac{S}{OA}(\hat{\beta}_{OA} - \beta_{PL}) + \frac{PA}{OA}(\beta_{PA} - \beta_{PL})\\ &= \frac{PA}{OA}(\beta_{PA} - \beta_{PL}) - \frac{S}{OA}\left[\frac{1}{1+L}(\beta_E - \beta_D) - (\beta_{PL} - \beta_D)\right].\end{aligned} \tag{12}$$

Plugging in the definition of $\hat{\varepsilon}_{OA}$, $\hat{\varepsilon}_{OA} = \frac{PA}{OA}(\beta_{PA} - \beta_{PL}) - \frac{S}{OA}[\beta_{OA} - \beta_{PL} + \hat{\varepsilon}_{OA}]$. Rearranging results in

$$\hat{\varepsilon}_{OA} = \frac{PA}{\hat{O}A}(\beta_{PA} - \beta_{PL}) - \frac{S}{\hat{O}A}[\beta_{OA} - \beta_{PL}]. \tag{13}$$

Thus one sufficient condition for $\hat{\varepsilon}_{OA} \geqslant 0$ is $\beta_{PA} \geqslant \beta_{PL}, \beta_{OA} \geqslant \beta_{PL}$, and $s \leqslant 0$. □

Proof of Eq. (5). From the accounting identity $OA + S = E + D$, $OA = E + (D - S)$, i.e., pension deficit is treated as a negative debt.

In terms of risk calculation, the miscalculated operating asset beta satisfies

$$\hat{\hat{\beta}}_{OA} OA = \beta_E E + \beta_D (D - S). \tag{14}$$

Thus the bias in the beta is given by

$$\begin{aligned}\hat{\hat{\varepsilon}}_{OA} &= \hat{\hat{\beta}}_{OA} - \beta_{OA} \\ &= \beta_E \frac{E}{OA} + \beta_D \frac{(D-S)}{OA} - \frac{E}{OA}\beta_E - \frac{D}{OA}\beta_D + \left[\frac{PA}{OA}\beta_{PA} - \frac{PL}{OA}\beta_{PL}\right] \\ &= \frac{PL - PA}{OA}\beta_D + \frac{PA}{OA}\beta_{PA} - \frac{PL}{OA}\beta_{PL} \\ &= \frac{PL}{OA}(\beta_D - \beta_{PL}) + \frac{PA}{OA}(\beta_{PA} - \beta_D). \qquad \square \end{aligned} \tag{15}$$

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