Journal of Accounting and Economics 57 (2014) 1–21

Contents lists available at ScienceDirect

Journal of Accounting and Economics

journal homepage: www.elsevier.com/locate/jae

Does freezing a defined benefit pension plan affect firm risk?☆

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ARTICLE INFO

Article history:
Received 19 January 2012
Received in revised form
26 September 2013
Accepted 1 November 2013
Available online 27 November 2013

JEL classification:
G30
G31
G32

Keywords:
Defined benefit pension plan
Firm risk
Risk-taking activities
Pension plan freeze

ABSTRACT

This paper examines the impact of a defined benefit (DB) pension plan freeze on the sponsoring firm's risk and risk-taking activities. Using a sample of firms declaring a hard freeze on their DB plans between 2002 and 2007, we observe an increase in total risk (proxied by the standard deviation of EBITDA and asset beta), equity risk (standard deviation of returns), and credit risk following a DB-plan freeze. The increase in credit risk is reflected in a decline in credit ratings and an increase in bond yields for freezing firms. When we examine investment strategies, we observe a shift in investment from capital expenditures before the freeze to more-risky R&D projects after the freeze, and an increase in leverage. These strategies (increased focus on R&D and higher leverage) increase the operating and financial risk the firm faces. Overall, we observe an increase in risk-taking following DB plan freezes, consistent with theories that DB plans act as “inside debt” that aligns managers' interests with bondholders'.

1. Introduction

This paper examines the effect of a change in the structure of a pension plan on a firm's risk and its risk-taking activities. A pension plan is an arrangement whereby an employer commits to making future payments to employees for service they have provided during their working years (Kieso et al., 2010, p. 1050). Pensions constitute a significant portion of many firms' total compensation costs. For example, (old) General Motors' pension and healthcare costs for retirees were about $1,784 per vehicle or $6.2 billion a year (Kieso et al., 2010, p. 1049), about 4% of (old) GM's total annual costs. With such a significant portion of costs spent on pension benefits, any change in the pension plan might have a significant impact on a firm's investment and strategic plans, and therefore the amount of risk stakeholders in the firm (especially stock and bondholders) are exposed to.

One change in pension plans that has become widespread since the early 2000s is the *freezing* of defined benefit (DB) pension plans. When a firm freezes a DB plan, it stops the future accrual of retirement benefits, and typically switches the participants in the plan to an alternate form of pension (typically defined contribution (DC), such as a 401(k) plan). While a DB-plan freeze does not relieve a firm of its existing commitment to pay out benefits already accrued, it does reduce the risk

☆ We would like to thank Yanling Guan, Po-Hsuan Hsu, Tse-Chun Lin, Joshua Rauh, an anonymous referee, and workshop participants at Hong Kong University, Drexel University, and SUNY Binghamton for helpful comments and suggestions.

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http://dx.doi.org/10.1016/j.jacceco.2013.11.004

associated with future retirement benefit accruals and, potentially, alters a firm's financial and operating strategies. This paper examines the impact of DB-plan freezes on overall firm risk and on the freezing firms' investment, operational, and financial risk-taking activities.

Sundaram and Yermack (2007) argue that DB pension plans are an important form of "inside debt." Specifically, Sundaram and Yermack (2007) report that more than half the CEOs of S&P500 firms have service-based, defined benefit pensions, and that those pensions are a substantial fraction of their overall incentive compensation. They argue that these typically unsecured debt-like claims on the firm (usually in the form of a Supplemental Executive Retirement Plan, or SERP) alter managerial incentives in a meaningful way by, at the margin, aligning the interests of managers more closely with those of *outside* debt holders (i.e., bondholders). This "debt bias" arises because managers generally bear the same default risk faced by the firm's other unsecured (outside) creditors.[1] As such, Sundaram and Yermack (2007) argue that as the firm's managers have more debt-like (pensions) versus equity-like (stock options) incentive compensation, the firm is likely to take on *less* risk. This is exactly what they find: "As the CEO's pension value increases relative to his equity value, risk taking as measured by distance-to-default declines." (p. 1555).

Other studies report similar findings. Edmans and Liu (2011) argue that debt-like compensation structures (such as pensions) are effective incentive mechanisms when managerial effort is productive in enhancing liquidation values in financial distress. Anantharaman et al. (2011) posit that private lenders recognize the incentive-alignment effects of inside debt and offer the firm more generous lending terms (lower spreads, fewer covenants) when the firm's managers are more exposed to debt-like compensation claims in the form of SERPs. Finally, Wei and Yermack (2011) report that bond prices rise and equity volatility falls for firms that disclose large inside debt positions (SERP and deferred compensation) in 2007 (the first year that SEC mandated such disclosure).

In this paper we argue that freezing a DB pension plan will have two potentially offsetting effects. On the one hand, the *direct* effect of freezing a DB plan is that firm risk is lowered because firms sponsoring DB plans guarantee the payout of a specific amount of benefits for the life of their employees upon their retirement. Therefore, firms with DB plans bear various risks associated with the provision of those future payouts, including the risk associated with the rate of return on the funds invested to provide future payouts and longevity/mortality risk of their employees. Thus the direct effect of freezing a DB plan is a reduction in this DB-plan induced risk.

On the other hand, DB-plan freezes might result in firms taking on more risk because, at the margin, the "debt bias" induced by inside debt positions becomes less important as executive retirement benefit begin to accrue in the form of DC plans. Over time, therefore, the "debt bias" should reduce and managers' incentives should be aligned with stockholders' to a greater extent.[2] We call this the *incentive* effect. It is an empirical question whether the incentive or direct effect dominates.

We find that the incentive effect outweighs the direct effect. Using a sample of firms that freeze their DB plans during the period 2002–2007, we observe a higher standard deviation of earnings (EBITDA) following DB-plan freezes. This change in freezing firms' risk is observed after controlling for the endogenous nature of a firm's pension freeze decision. Our analysis of the firm's equity and credit risk suggest that both increase after the freeze. The standard deviation of stock returns is higher in the five years after the freeze compared to the five years before the freeze. Our analysis of credit ratings and bond yields provides independent confirmation of this increase in risk: credit ratings of freezing firms decline and the required yields on publicly traded debt increase after the freeze event.

When we evaluate investment, financing, and operating strategies of these firms in the pre- and post-freeze periods, we observe that freezing firms tend to invest more in high risk R&D projects and less in capital expenditure after the DB plan freeze (compared to pre-freeze investment). Notably, the increase in R&D intensity of DB-plan freeze firms during our sample period is in stark contrast to a reduction in R&D expenses in the post-SOX period (which coincides with our sample period) documented by Bargeron et al. (2010). DB-plan freeze firms also increase leverage in the post-freeze period. However, we do not observe any significant change in diversification or focus (as an operating strategy) in these firms. These results continue to hold after controlling for CEOs' equity-based compensation, change in CEOs, tenure of CEOs, and the number of years a CEO has credited in the firm's retirement plan. The results are also robust to controlling for the endogenous nature of the DB-plan freeze decision. Collectively, our results suggest that firms become more aggressive and tend to take on more investment and financing risk following DB-plan freezes.

This is an important research topic because of both the number of employees in the U.S. that are covered by defined benefit pension plans and the speed (and breadth) at which such pension plans are being converted into alternate forms

[1] Certain DB-plan benefits are guaranteed by the U.S. federal government via the Pension Benefit Guaranty Corporation (PBGC), and also are not available to other creditors of the firm in the event of default. However, such guaranteed/protected benefits are capped at a maximum level—the PBGC cap is now $54,000 a year for a 65-year-old and younger workers get less (Wall Street Journal, 12/16/2011)—that would be far below the benefits expected to be received by senior managers, and none of the pension benefits in a SERP plan are protected either by the PBGC or from other unsecured creditors. For example, while the PBGC has paid full benefits to 78% of employees at airlines it has bailed out in the past, pilots and other high earners get only a portion of their notional benefits because of the caps on the agency's payment (Wall Street Journal, 12/16/2011). As such, DB-plan benefits for senior executives are debt-like unsecured claims on the firm. As discussed later in the paper, when firms freeze their DB plans they almost always freeze *both* the "rank-and-file" (a.k.a. "qualified") and SERP (a.k.a. "non-qualified") plans.

[2] While the value of *existing* pension obligations is typically not changed by a DB-plan freeze (see Section 2.2. for more details), the relative importance of the inside debt position declines over time as executives accrue more equity-like incentive compensation and retirement benefits in the form of DC pensions.

(such as defined contribution). Comprix and Muller (2011) suggest that the period between 2004 and 2007 contains the largest number of hard pension freezes by U.S. firms. Wyatt (2010) also reports that the percentage of Fortune 1000 firms that sponsor DB plans and do not have any frozen plans declines from 59% in 2004 to 38% in 2010. Furthermore, given that risk-taking at the firm level is topical and relevant, it is essential to understand how a change in pension policies affects the incentives of managers to take on risk in other parts of their operations.

This paper contributes to both the pension and corporate finance literature by suggesting that the impact of a change in the nature of a pension plan is not limited to the affected employees and their benefits. The results of this study suggest that, in addition to the explicit cost of contributing to a pension plan, DB-plan sponsoring firms also incur implicit restrictions (driven by the "debt bias" induced by large inside debt positions) on their firm's strategy, which may have a long-term impact on the firm's profitability and shareholder value.

Most extant studies on DB pensions have focused on explicit DB-plan liabilities, and how these liabilities affect a firm's valuation or investment behavior (Bodie et al., 1987; Bodie and Papke, 1992; Feldstein and Morck, 1983; Feldstein and Seligman, 1981; Oldfield, 1977; Rauh, 2006). To our knowledge, no previous study has examined the effects of *freezing* DB pension plans on firms' risk taking, although there is an extensive literature (cited earlier) about the effects of the existence of DB pension plans per se on various corporate policies and outcomes (via "inside debt" incentives). There have been prior studies of DB-plan freezes, focused mainly on the market reaction to the announcement of freeze events. Milevsky and Song (2010), for example, observe a positive abnormal return of 3.8% around the announcement that a firm will freeze its DB plan and shift to a DC plan. On the other hand, McFarland et al. (2009) find negative abnormal returns around pension plan freeze announcements. This paper extends these studies by examining the impact of pension freezes on firms' risk-taking and stock return volatility.

The remainder of this paper is organized as follows. In Section 2, we review defined benefit (DB) and defined contribution (DC) pension plans, and discuss freezes/terminations thereof. In Section 3 we develop our hypotheses. Section 4 describes our sample. Section 5 documents our empirical analyses and results. Section 6 details sensitivity analyses, and Section 7 concludes.

2. Pension plans

2.1. *Defined benefit and defined contribution plans*

Defined benefit (DB) and defined contribution (DC) plans are the two most common types of pension plans. In a DB plan, the employer guarantees to pay the employee a specific level of benefits from their retirement until their death. In a DC plan (including Individual Retirement Account (IRA) and 401(k) plans), the employer makes a contribution every year to an employee's individual account (typically a multiple (or a match) of the employee's own contribution) but does not guarantee the employee's income during retirement.

In general, DC plans are cheaper for employers than DB plans are, and entail lower risk for the sponsoring firm. According to a study by Pricewaterhouse Coopers (2005), defined benefit plans cost about five to seven percent of payroll, while defined contribution plans cost only about three percent (Kieso et al., 2010; Munnell and Soto, 2004; Munnell and Sunden, 2004).

In addition to the difference in costs, these two types of plans impose different levels of risk on the sponsoring firms. Under DB plans, sponsoring firms guarantee the payout of a specific amount of benefits for the life of their employees upon their retirement, and so firms with DB plans have to bear various risks associated with the provision of those future payouts. These include the risk associated with the rate of return on the funds invested to provide future payouts and longevity/mortality risk (Munnell et al., 2007). Any change in these factors can have a significant effect on the required payout or the funds available for distribution, and hence the contribution required in the current period to meet these expected future payouts.

Firms with DC plans, on the other hand, transfer most of these risks to their employees. Under DC plans, the sponsoring firms contribute a predetermined amount to individual employees' accounts (typically a "match"), but employees are responsible for choosing the ways in which those funds are invested and for the investment return on their own accounts (which will pay for their retirement benefits). If the employees outlive their DC plan balance, they have to make up the difference themselves. Hence, sponsoring firms shift the risks associated with investment returns and the longevity of employees to the employees in a DC plan (compared to a DB plan).

Historically, the occupational pension system in the U.S. was designed for, and dominated by, DB plans, while DC plans were only offered by small firms or as supplementary plans (Broadbent et al., 2006). However, there has been a steady increase in the adoption of DC plans since 1975, the year following the passage of the Employee Retirement Income Security Act (ERISA).[3] Furthermore, in the last two decades, a shift in pension coverage from DB plans to DC plans has occurred in the U.S. (Byrnes, 2006; Munnell et al., 2007). According to the 2008 Private Pension Plan Bulletin (Private Pension Plan Bulletin, 2008) report based on information collected from U.S. firms' Form 5500 filings with the U.S. Department of Labor, the number of DB pension plans decreased 42.3 percent between 1975 and 2005. Conversely, the number of DC plans multiplied by about 8-fold from 8,587 in 1975 to 67,678 in 2005.[4]

[3] U.S. Development of Labor Employee Benefits Security Administration, Private Pension Plan Bulletin, February 2008.

[4] Only pension plans with 100 or more participants are included in these statistics. The statistics include single employer plans, plans of controlled groups of corporations, and multiple-employer non-collectively bargained plans.

In addition to "rank and file" pension plans (also known as "tax-qualified" plans), many firms have supplemental retirement plans intended for senior executives. Such plans are known generically as "supplemental executive retirement plans" or SERPs. The reason for their existence is that the pension benefits for most senior executives would vastly exceed the maximum federally insured amounts available to "rank and file" workers under tax-qualified DB pension plans. Senior executives usually participate in a company's ordinary (tax-qualified) plan up to the maximum amount, but the overage of their pension entitlements (which can be substantial) is covered by a SERP. SERP pension liabilities represent unsecured, unfunded debt claims against the firm: if the firm becomes insolvent, SERP pension beneficiaries would rank with other unsecured creditors in terms of their claims against the firm. In other words, SERP pension liabilities are neither protected from other creditors nor protected by the US government via the Pension Benefit Guaranty Corporation (PBGC). This is why prior literature refers to such claims as "inside debt" (e.g., Sundaram and Yermack, 2007; Wei and Yermack, 2011).

2.2. *Defined benefit pension plan freezes and terminations*

A *freeze* of a DB plan differs from a *termination* of a DB plan. When a firm *terminates* its DB plan, it brings closure to the DB plan, and has to make either a lump sum payment of the pension benefits or purchase annuities from an insurance company for covered employees, within a reasonable time after the termination (i.e., standard termination). If a bankrupt firm cannot make the required benefit payments on a tax-qualified plan (i.e., not including SERPs), the liability is transferred (at a substantially reduced level) to the PBGC (i.e., distressed termination). Watson Wyatt reports that half of the firms that terminate their DB plans dropped off the Fortune 1000 list in the following year, suggesting that the termination decision is often caused by weak financial condition. DB-plan termination is subject to restrictions imposed by the PBGC. These restrictions include, for example, that no underfunded plan can be terminated except in bankruptcy; in case of overfunded plans, an excise tax of up to 50% can be imposed on the termination of the plans.

DB-plan *freezes*, on the other hand, do not require the immediate payment of pension benefits to employees. When a firm freezes its DB plan, it keeps the plan but stops accruing benefits for some or all employees. Pension assets remain in the trust and payment will be made to employees upon their retirement. There are three different types of freeze a firm can impose on its DB plan: hard/total, soft, and partial. In a hard/total freeze, the firm completely stops the accrual of future benefits to all participants. That is, there is no further accrual of benefits even to existing plan participants. A soft freeze, on the other hand, means that the plan is closed to new entrants but the accrual of benefits of current participants continues (potentially with a change in the formula used to compute the future plan benefits). In a partial freeze, the firm ceases or limits the accrual of further benefits for some but not all participants.

During the 1980s and early 1990s, DB-plan freezes (or terminations) were limited mostly to firms facing bankruptcy or engaged in mergers and acquisitions. However, with the increase in the popularity of DC plans (relative to DB plans) among large, healthy firms, there has been an increase in DB-plan freezes among Fortune 1000 firms since the early 2000s (Wyatt, 2007). Some firms that froze their DB plans during our sample period include Motorola, Inc., which froze its pension plan to new employees in 2004; Lockheed Martin, Hewlett-Packard, and Sears Holdings followed suit and froze their DB plans in 2005, and Coca-Cola Bottling and IBM did so in 2006 (Munnell et al., 2007). These large, healthy companies offered a 401(k) plan, or improved their existing 401(k) plan, after their DB-plan freeze.

Among these (relatively) healthy firms that freeze their DB plans, the most widely cited reason is to reduce costs in order to remain competitive in the global marketplace (Aon Consulting, 2003; Hewitt Associates, 2006; Mercer Human Resource Consulting, 2006; Munnell et al., 2007). Other reasons suggested by pension studies for the rise in DB freeze include a long-term increase in labor force mobility (leading to a demand for retirement-benefit portability: Schrager, 2006) and increases in health care costs (Atanasova and Hrazdil, 2010; Munnell et al., 2007).[5]

In this paper, we focus on the effect of DB-plan *freezes*, rather than terminations, because a significant portion of terminations during our sample period are the result of financial distress or bankruptcy.[6] Since we are interested in investment, financing, and operational strategies after a change in the structure of a pension plan, it makes little sense to consider changes that are "involuntary" because managers of distressed firms likely face different incentives than managers of healthy firms do. Among the three types of pension freezes, we focus on firms that impose a hard freeze on their plans. Hard freezes likely lead to the most significant change in managerial incentives because (relative to soft and partial freezes) hard freezes change the importance of inside debt by the most. Hence, if DB-plan freezes have any impact on a firm's strategy or investment, the effects are likely to be the strongest among firms that install a hard freeze (as opposed to those with soft or partial freezes).

[5] Changes in tax codes provide another important determinant of the time-series of DB-plan freezes/terminations. For example, the mid-1980s introduction of an excise tax of up to 50% on the reversion of surplus pension assets to the sponsoring firm (Section 4980 of the Internal Revenue Code) upon DB-plan termination slowed down the plan termination rate (Nadel and Nager, 1992). Petersen (1992) argues that this excise tax on asset reversions reduced plan terminations by 36 percent in 1986 alone.

[6] A large fraction of firms freeze their DB pension plans in periods prior to a standard termination. If the freeze (or termination) has any impact on a firm's risk or strategies, we should observe the change when the firms first decide to freeze their plans. Whether a (standard) termination has any incremental significant impact on firm risk and strategies is a question for future research.

When firms freeze their “rank and file” (i.e., “qualified”) DB pension plans they almost always also freeze participation in their “excess” plans for senior executives (SERP, or “non-qualified” plans).[7] We examine a random sample of freeze announcements by firms in our sample, and without exception the SERP (non-qualified) plans are frozen at the same time as the “rank and file” (qualified) DB pension plans are.

3. Hypotheses

A DB pension plan, and specifically the funds held within a SERP, represents the portion of senior executives' compensation that resembles an unsecured debt claim against the firm. The amount that the executives will receive upon and beyond their retirement depends on the firm's performance and solvency, and such funds are neither protected from other creditors (in bankruptcy) nor protected by the PBGC.

When a firm freezes its DB plan and shifts retirement contributions to a DC plan, it reduces this portion of debt-like compensation of senior executives. Specifically, while the pension balances held within SERPs typically continue to exist (i.e., are not terminated), their effect on executives' incentives diminishes as the accrual of such benefits is typically frozen at the same time as the “rank and file” DB plan is frozen. Furthermore, post-freeze retirement assets are accumulated in DC (such as 401(k)) plans. DC pension plans insulate retirement wealth from firm-specific performance, unless, of course, the employees invest their 401(k) assets in the firm's stock. Even in this latter case, however, the retirement wealth of senior executives will, over time, more and more resemble an *equity-like* claim on the firm rather than a *debt-like* claim. Regardless of where senior executives choose to invest their DC plan contributions, the freezing of DB plans will, over time, reduce the fraction of senior executives' compensation that resembles an unsecured debt claim against the firm (“inside debt”).

This reduction in “inside debt” unambiguously aligns senior executives' incentives more closely with those of shareholders as opposed to debtholders. Prior studies document that DB plans help align the incentives of management with those of debtholders and weakens their incentives to transfer wealth from debtholders to shareholders (Anantharaman et al., 2011; Edmans and Liu, 2011; Sundaram and Yermack, 2007). A substantial change in the firm's organization of pension assets is likely to result in a substantial realignment of managerial incentives. We argue that this realignment may motivate managers to take on more risk because their compensation consists of more equity-based, and less debt-based, pay. We call this the *incentive* effect.

If managerial incentives to take risk increase, we would expect to observe higher volatility of fundamental earnings (earnings before interest, taxes, and depreciation; EBITDA), higher stock return volatility, and lower credit quality (i.e., lower ratings and higher required bond yields). We also investigate whether changes in firm risk come from firms adjusting their financial or operational strategies. Specifically, we examine the form of investment (Capex vs. R&D), leverage, and operational diversification. Prior research documents that investment in R&D is associated with an increase in stock return volatility while investment in property, plant and equipment is negatively related to return volatility (Coles et al., 2006). Furthermore, Bhagat and Welch (1995) and Kothari et al. (2002) also view R&D expenditures as more risky investment relative to capital expenditures.

Increasing leverage is a financial policy choice that clearly increases risk. Firms generally adopt a strategy of diversification (multiple, unrelated lines of businesses) in order to produce more stable cash flows and lower the operating risks associated with a single product or line of business.[8] Comment and Jarrell (1995) demonstrate that more focused (less diversified) firms are riskier, in the sense of having higher idiosyncratic return volatility. Therefore, we might also observe the increased incentive to take risk manifesting itself in more focused firms after DB-plan freezes.

The *direct* effect of a DB-plan freeze, however, is that the freeze event reduces the firm's risk. Specifically, DB plans guarantee the payout of a specific amount of benefits for the life of their employees upon their retirement. Therefore, firms sponsoring DB plans have to bear risks associated with the provision of those future payouts, including the risk associated with the rate of return on funds invested to provide future payouts and employee longevity/mortality risk (Munnell et al., 2007). Firms with DC plans, on the other hand, transfer most of these risks to their employees. Given that this direct effect is related to both the qualified and non-qualified parts of a firm's DB plan, while the incentive effect is related mostly to the non-qualified SERPs only, whether the direct effect dominates the incentive effect is an empirical question.

4. Sample and descriptive statistics

We collect DB pension freeze data from the Department of Labor's Form 5500 for the years 2002 to 2007.[9] Pension plan sponsoring firms have to file Form 5500 by the last day of the seventh month after their plans' year ends in order to comply with the reporting requirement of The Employee Retirement Income Security Act (ERISA, 1974) and the Internal Revenue Code. The form was jointly developed by the Department of Labor, the Internal Revenue Service (IRS), and the Pension

[7] For example, when Sears froze its qualified plan (“Sears Pension Plan”) on December 31, 2005, it also froze the two non-qualified plans. Similarly, when Motorola decided to freeze its qualified Motorola Pension Plan on December 31, 2004, it also froze the Motorola Supplemental Pension Plan (“MSPP”), a non-qualified plan.

[8] The virtue of which is beyond the scope of this paper, but see Amit and Livnat (1988), Lang and Stulz (1994), and Wernerfelt and Montgomery (1988).

[9] Our sample period stops in 2007 for two reasons. First, with the start of the Global Financial Crisis in late 2007, the change in firm risk, investment, and financing policies may be impacted by the change in the macro-economy and not at the discretion of management. Second, the last year available in the database where we collect our pension freeze data from is 2007.

Benefit Guaranty Corporation. We search Form 5500 for firms that imposed a hard freeze on their DB plans during the sample period.

We begin collecting pension freeze data from 2002 because although 2001 is the first year firms reported DB pension freeze on Form 5500, no firms reported a freeze in that year. Only firms with a *hard* freeze of their pension plan are included in our freeze sample. All other firms that file Form 5500 are considered as non-freeze sample observations. After ensuring that the freezing firms have data in both the Compustat (accounting data) and CRSP (stock returns) databases, we are left with 116 firms with the required accounting and return data that institute a hard freeze on their DB pension plans during our sample period.[10]

Our analysis of accounting, stock return, and bond yield data for firms instituting a DB-plan freeze involves different intervals of measurement depending on the variables being used in the analysis. Specifically, our stock return volatility measures use daily returns over calendar quarters. We measure total return volatility at the quarterly interval as the (natural) log of the standard deviation of daily excess returns during the quarter, where excess returns are raw returns minus the risk-free rate. We also measure the variance of daily abnormal returns over the same intervals, where abnormal returns are the residuals from Fama-French three-factor models estimated using five years of daily return data with coefficients estimated separately in the pre- and post-freeze periods.[11] We obtain these measures for the 20 calendar quarters (i.e., five years) before and after the pension freeze year.

Our bond data, such as yield and maturity, are obtained from the Trade Reporting and Compliance Engine (TRACE) database developed by FINRA. That is, our analysis of bond yields for firms freezing their DB pension plans is limited to those firms with OTC bond trading data reported in TRACE. Since the first year data are reported in TRACE is 2002, our analysis of bond yield starts in 2002. The TRACE database contains transaction information on the over-the-counter (OTC) secondary market trades of eligible corporate bonds of FINRA members (including high-yield and unrated debt, medium-term notes, convertible debt, floating rate notes, etc…). TRACE is a real-time reporting system for OTC bond trades, and contains such data as the time of execution, price, yield, and volume of the trade.

We compute the trade-size weighted average yields of all trades executed within the quarter for each firm and use this as the dependent variable in our bond analyses. The trade-size weighted average yield takes into account the relative size of each trade, and is defined as the sum of the trade-size weighted yields implied by each trade (where trade-size weights are calculated using the trade's proportion of the bond's total trade value during the quarter).

These return volatility and bond yield measures are then merged with quarterly accounting data from Compustat for the fiscal quarter that ends immediately prior to the beginning of the calendar quarter (typically the prior day). Because we do not know exactly when during the freeze year the DB plan is frozen, we exclude the entire freeze year from these analyses for each firm.

Our analyses of earnings volatility are similarly based on quarterly data. However, our analyses of credit ratings, investment, financing, and operating strategies use accounting data collected at the annual frequency, because credit rating and most of the pension data used as control variables in these analyses are only reliably available at the annual frequency. We collect annual data for the pre- and post-freeze periods from 1999 to 2009, and our control variables use Compustat data from the prior fiscal year.[12]

Fig. 1 describes the time-series of hard pension freezes in our sample. DB-plan freezes peak in 2003 and 2006. The peak in 2003 is likely driven by regulatory uncertainty and the series of accounting scandals that led to the implementation of the Sarbanes-Oxley Act in 2002, as firms freeze their DB plans in order to lower their exposure to investment return risks and potential legislation associated with DB plans. The peak in 2006 can, at least partially, be attributed to the passage of the Pension Protection Act and the issuance of Statement of Financial Accounting Standards (SFAS) 158. The adoption of SFAS 158 significantly increased the reported pension liabilities of, and the volatility of reported income for, firms with DB plans. Firms with DB plans were more likely to freeze their plans in 2006 given the uncertainties introduced by this new accounting standard. The industry distribution of DB-plan freezes in our sample is provided in Fig. 2. A large portion of our sample is from the manufacturing sector, which is also the largest sector in the Compustat population.

Table 1 provides summary statistics for our sample. Panel A compares the pension plan and firm characteristics between firms that freeze their DB plans and those who do not impose such a freeze. We include all firm-years with the required pension plan and freeze data on Form 5500. Based on the information on Form 5500, we classify the firms into DB-plan freeze firms (i.e., the 116 firms that announced a DB-plan freeze during our sample period) and non-freeze firms. As can be seen in Panel A, firms that freeze their DB plans tend to have plans with lower funding ratios (computed as the pension plan assets divided by the projected benefit obligation) and are more likely to be underfunded. Compared to non-freeze firms, freezing firms are more likely to have suffered a loss, less likely to have cut their capital expenditure and R&D expenses in the prior period, and their pension plans are less likely to be subject to collective-bargaining agreements.

[10] In our sample, each firm institutes a hard freeze on their pension plans only once.

[11] Risk-free rates and the Fama-French factors are taken from Ken French's website.

[12] Because data on pension contribution (one of our control variables) are available for most firms starting from 1998, we require our firms to have three years of annual data in the pre- and post-freeze period in order to be included in our investment and financial strategy analyses. Had we imposed a five-year data requirement in both pre- and post-freeze periods, we would have had to drop all pension freezes announced in 2002 and 2003 from our sample: this would have significantly reduce our sample size.

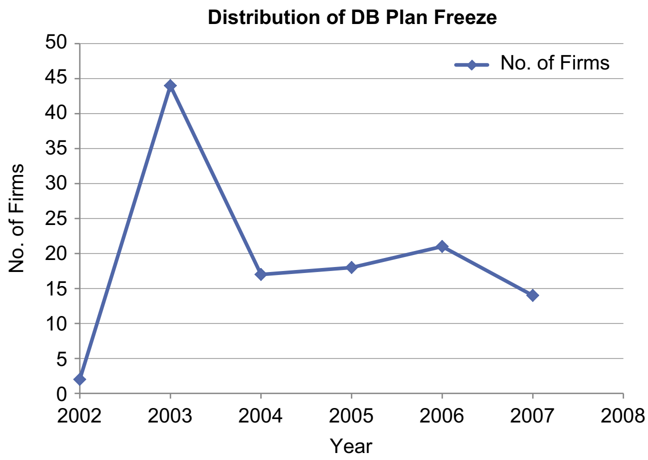

Fig. 1. Distribution of defined benefit pension plan freezes by year.

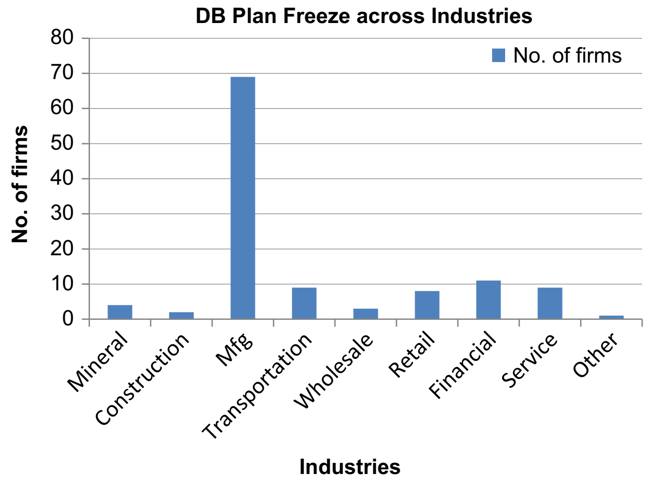

Fig. 2. Distribution of defined benefit pension plan freezes by industry.

Panels B and C present the freeze firms' characteristics and univariate differences between the pre- and post-freeze periods. Panel B contains summary statistics for the quarterly data used in our return volatility and bond yield analyses, while Panel C shows summary statistics for annual data used in our analyses of investment, financing, and operating strategies.

The average market value of equity (Panel B) for our sample freeze firms is about $5.5bn–$7bn, with the post-DB-plan-freeze increase consistent with the bull market in the middle of our sample period (and the growth in sales). The average firm in our sample has about a 30% book leverage ratio (book value of debt to total assets). Comparing the pre- and post-freeze periods, we observe an increase in firm performance and valuation: ROA, sales growth, and the market-to-book (asset) ratio all increase significantly for firms with DB-plan freezes. Whether measured using accounting or stock returns, or using excess or abnormal stock returns, Panel B of Table 1 also shows a significant *decrease* in return volatility following DB-plan freezes. This reduction in observed accounting and stock return volatility is somewhat deceptive, because the univariate statistics do not control for the strong time trend in return volatility. In contrast to the trend in Campbell et al. (2001) (who study a different time period), average idiosyncratic risk for our sample firms displays a marked *downward* time trend over our sample period.[13] Multivariate regressions (which control for the time trend) will reveal that both earnings and stock return volatility *increased* markedly for our sample firms in the post-freeze period relative to the pre-freeze period.

[13] This does not necessarily imply that the *upward* trend in idiosyncratic volatility noted in Campbell et al. (2001), whose sample period finishes in 1997, does not apply during our sample period (1998 onwards). We have a relatively focused sample of 116 firms imposing DB-plan freezes, and while idiosyncratic risk declines on average for these firms over the 2000–2009 period (using the same metrics employed in Campbell et al. (2001)), the same is not necessarily true for all firms.

Table 1
Summary statistics.

This table presents the summary statistics for our firm-year and firm-quarter observations based on our sample of firms that declare a freeze on their defined benefit (DB) pension plans between 2002 and 2007. We include all firm-years with the required pension plan and freeze data on Form 5500. Based on the information on Form 5500, we classify firms into DB-plan freeze firms (i.e., those firms announced a DB-plan freeze during our sample period) and non-freeze firms. For the DB-plan freeze firms, we further classify the annual observations into pre-freeze and post-freeze periods. We then merge these observations with Compustat data to retrieve the required financial data and other pension data for our analyses. We conduct several types of analyses that use data at different frequencies and over different time periods (conditional on data availability).

Panel A presents descriptive statistics for the annual observations used in our analysis of the choice to freeze a DB pension plan. The comparison between DB freeze firms and non-freeze firms is based on data from 1999 to 2009: pension contribution data are available from Compustat starting from 1998 only, and because we use lagged variable in our analyses the first available sample year is 1999. The non-freeze sample, as desrcibed above, is all firms that filed Form 5500 (with the required Compustat data) that did not freeze their DB pension plans during our sample period. *Underfund* is an indicator variable that equals one if the projected benefit obligation is greater than the pension plan assets; zero otherwise. *Funding%* is the funding status of pension plan and equals pension plan assets divided by the projected benefit obligation. *Firm Size* is the log of total assets ($ millions). *Plan Size* equals projected benefit obligation divided by total assets. *Operating Cash Flow* is the cash flow from operations scaled by total assets. *Loss* is an indicator variable equals to one if the firm suffers a loss in the prior year, and zero otherwise. Δ*Sales%* is the percentage change in sales. Δ*Dividend* is the change in dividend payout in the prior year. Δ*Leverage* is the change in debt to asset ratio in the prior year. Δ*R&D* is the change in research and development expense (R&D) to asset ratio in the prior year. Δ*Capex* is the change in capital expenditure to asset ratio in the prior year. *Union plan* is an indicator variable that equals one if the DB plan is subject to a collective-bargaining agreement, and zero otherwise.

Panel B presents descriptive statistics for the quarterly sample used in our volatility of returns, volatility of earnings, credit rating, and bond yield analyses. We collect variables used in our comparison between the pre- and post-freeze periods from 1997 to 2009 for the return and earnings volatility and credit ratings analyses, and from 2002 to 2009 for the bond yield analysis (limited by the availability of Trace data). *Std EBITDA* is the standard deviation of earnings before interest, tax, depreciation, and amortization scaled by total assets, measured over the prior 12 quarters. *Std ROA* is the standard deviation of net income scaled by total assets (ROA), measured over the prior 12 quarters. *Std excess returns* is the quarterly standard deviation of daily excess stock returns, where daily excess stock returns are raw returns minus the daily risk-free rate from Ken French's website. *Std abnormal returns* is the quarterly standard deviation of daily abnormal stock returns, where daily abnormal stock returns are the residuals from a Fama-French three-factor model estiamted separately (in-sample) for the pre- and post-freeze periods. *Sales* is the net sales of the quarter. *M/B (assets)* is the market to book ratio of assets, computed as the ratio of market value of assets (book value of assets minus book value of equity plus market value of equity) to their book value. *ROA* is the return on assets, computed as income before extraordinary items divided by total assets at the beginning of the year. *Leverage* is the debt (current debt+long-term debt) to total assets ratio. *R&D* is the research and development expense divided by total assets at the beginning of the year. *Capex* is annual capital expenditures minus the sale of property, scaled by total assets. *Market value of equity* ($ millions) is the market price of stock at the beginning of the year multiplied by shares outstanding. *Credit rating* is the Standard & Poor credit rating of the firm's long-term debt. We convert the letter rating to a numerical value as follows: AAA ratings are assigned a value of 1 and the difference between each grade (e.g. between AAA and AA+) is 1/22=0.045 (because there are 22 ratings categories), implying that a bond with the rating of D will be assigned a value of 0.045. *Yield (%)* is the trade-size weighted average yield of all the firm's bonds traded in the OTC market during the quarter. The trade-size weighted average yield is the sum of the trade-size weighted yields implied by each trade (where trade-size weights are calculated using the trade's proportion of the bond's total trade value during the quarter). *Debt/equity* is the ratio of the book value of debt to the market value of equity. *Profit margin* is computed as income before extraordinary items divided by sales of the quarter. *Times interest earned* is computed as the sum of net income, interest expense and income tax divided by interest expense. *Subordinated* measures the proportion of the firm's bonds traded during the quarter that is subordinated bond. *Maturity* is the trade-size-weighted average maturity of all the firm's bonds traded in the quarter. The trade-size-weighted average maturity is computed in the same way as the trade-size-weighted-average yield. *Treasury bond yield* is the yield of U.S. Treasury securities with corresponding maturity as the firm's bonds traded in the quarter. If there is not an exact match of maturity, we use Treasury securities with the closest maturity. *Premium on AAA bonds* is the average yield on Moody's AAA bonds less the average yield on 30-year U.S. Treasury bonds.

Panel C presents descriptive statistics for the annual sample used in our investment, financing, and operational strategy analyses, based on data from 1999 to 2009. *Segment herfindahl* is computed as the sum of the squared segment sales divided by the square of total firm sales. *Total assets* ($ millions) is the book value of assets measured at the beginning of the year. *Sales growth* is the growth in sales from year $t-2$ to year $t-1$. *Std*(*ROA*) is the standard deviation of ROA, computed using ROA in a three-year trailing window. *Non-pension cash flows* is computed as income before extraordinary items plus depreciation and amortization plus net periodic pension costs, scaled by total assets at the beginning of the year. *Pension contribution* is the employer's contribution to the pension fund scaled by total assets. *ΔGDP* is the percentage change in GDP. *SOX* is an indicator variable that takes on a value of one if the observation is taken from a period after the passage of the Sarbanes-Oxley Act (i.e. July 30, 2002), zero otherwise. *Net PP&E* is the value of property, plant and equipment, net of accumulated depreciation, scaled by total assets. *Zmijewski's score* is computed as: $-4.336-4.513 \times ROA+5.679 \times Leverage+0.004 \times Liquidity$. *Dividend cut* is an indicator variable that equals one if the firm lowers its dividend in the fiscal year and zero otherwise. In all panels, tests of significant differences between the two periods use both parametric (*t*-statistics for means) and nonparametric (Wilcoxon rank-sum *z*-statistics for the median) statistics. ***, **, or * denotes statistical significance at the 1%, 5%, or 10% level (respectively).

Panel A: Descriptive statistics for annual data used in pension freeze analyses

	Non-freeze				**Freeze**				**Test statistics (non-freeze)**	
Variable	***N***	**Mean**	**Std dev**	**Median**	***N***	**Mean**	**Std dev**	**Median**	***t*-Statistic**	**Wilcoxon *z*-statistic**
Underfund	6,928	0.692	0.462	1	6,338	0.881	0.324	1	−27.046***	−26.331***
Funding%	6,928	0.909	0.258	0.872	6,338	0.814	0.260	0.826	21.034***	21.740****
Firm Size	6,928	8.499	2.243	8.574	6,338	8.781	2.124	8.859	−7.403***	−7.623***
Plan Size	6,928	0.240	0.281	0.158	6,338	0.224	0.284	0.127	3.251***	6.637***
Operating Cash Flow	6,928	0.092	0.076	0.087	6,338	0.091	0.087	0.083	1.002	0.327
Loss	6,928	0.165	0.372	0	6,338	0.186	0.389	0	−3.049***	−3.048***
Δ*Sales%*	6,928	7.538	26.089	5.094	6,338	7.727	120.054	5.998	−0.128	−0.758

ΔDividend	6,928	−0.013	2.488	0	6,338	0.030	0.788	0	−1.331*	−14.003***
ΔLeverage	6,928	−0.002	0.088	−0.005	6,338	0.001	0.077	−0.004	−1.413*	−1.052
ΔR&D	6,928	−0.001	0.012	0	6,338	−0.000	0.007	0	−4.494***	−10.347***
ΔCapex	6,928	−0.005	0.035	−0.001	6,338	0.000	0.032	−0.000	−8.644***	−9.781***
Union plan	6,928	0.298	0.457	0	6,338	0.272	0.445	0	3.302***	3.300***

Panel B: Descriptive statistics for quarterly data used in return volatility and bond yield analyses

	Pre-freeze				**Post-freeze**				**Test statistics (pre–post)**	
Variable	***N***	**Mean**	**Std dev**	**Median**	***N***	**Mean**	**Std dev**	**Median**	***t*-Statistic**	**Wilcoxon *z*-statistic**
Std EBITDA	976	0.014	0.012	0.010	663	0.011	0.009	0.008	2.77***	0.893
Std ROA	1,197	0.020	0.025	0.011	1,037	0.019	0.033	0.009	1.244	24.82***
Std excess returns	1,753	0.033	0.023	0.027	1,576	0.031	0.021	0.025	2.86***	4.32***
Std abnormal returns	1,753	0.031	0.023	0.025	1,576	0.026	0.019	0.021	6.58***	8.10***
Sales ($m)	1,771	931.84	1,675.14	218.18	1,590	1,283.21	2,479.44	311.90	−4.86***	−5.97***
M/B (assets)	1,771	1.607	1.170	1.295	1,590	1.640	0.734	1.413	−0.97	−5.75***
ROA	1,771	0.005	0.031	0.008	1,590	0.011	0.027	0.012	−6.08***	−7.68***
Leverage	1,771	0.309	0.239	0.272	1,590	0.280	0.222	0.244	3.67***	4.36***
R&D	1,771	0.004	0.010	0.000	1,590	0.004	0.009	0.000	−0.29	−1.58
Capex	1,771	0.193	2.634	0.597	1,590	0.171	2.674	0.454	0.24	3.04***
Market value of equity ($m)	1,771	5,518.00	20,633.31	588.95	1,590	6,868.05	18,394.35	1,029.16	−1.99**	−6.46***
Credit rating	238	0.569	0.165	0.591	214	0.528	0.192	0.545	2.45***	2.40**
Yield (%)	156	27.805	113.009	5.318	678	21.560	79.088	5.823	0.81	−3.14***
Debt/equity	156	0.404	0.363	0.281	678	0.682	1.287	0.337	−2.67***	−0.91
Profit margin	156	0.064	0.076	0.047	678	0.046	0.151	0.056	1.47	−0.45
Times interest earned	156	7.088	8.484	5.096	678	8.405	11.977	5.452	−1.30	−0.75
Subordinated	156	0.180	0.699	0.000	678	0.706	1.210	0.000	−5.23***	n/a
Maturity	156	106.802	71.816	94.5	678	106.23	74.588	83.677	0.09	0.89
Treasury bond yield (%)	156	4.079	0.931	4.287	678	3.382	1.257	3.497	6.52***	6.48***
Premium on AAA bonds	156	0.620	0.182	0.603	678	0.913	0.415	0.807	−8.61***	−9.85***

Panel C: Descriptive statistics for annual data used in investment, financing, and operational strategy analyses

	Pre-freeze				**Post-freeze**				**Test statistics (pre–post)**	
Variable	***N***	**Mean**	**Std dev**	**Median**	***N***	**Mean**	**Std dev**	**Median**	***t*-Statistic**	**Wilcoxon *z*-statistic**
Capex	414	0.043	0.045	0.034	350	0.042	0.053	0.027	0.46	1.72*
R&D	437	0.018	0.034	0.006	350	0.020	0.042	0.005	−0.68	0.01
Leverage	437	0.266	0.204	0.244	350	0.270	0.223	0.221	−0.31	0.54
Segment herfindahl	360	0.669	0.283	0.621	200	0.881	2.736	0.609	−1.46	−0.90
ROA	437	0.026	0.092	0.031	350	0.047	0.090	0.051	−3.22**	−4.07***
Total assets ($m)	437	11,772	48,668	1,491	350	12,036	58,248	1,131	−0.07	2.05**
Sales growth	437	0.066	0.260	0.041	350	0.106	0.267	0.083	−2.13**	−4.25***
Std(ROA)	437	0.043	0.074	0.020	350	0.049	0.094	0.024	−1.02	−2.99***
M/B (assets)	437	1.515	0.758	1.256	350	1.735	0.754	1.480	−4.06***	−5.41***
Non-pension cash flows	437	0.074	0.0996	0.079	350	0.089	0.094	0.091	−2.19**	−2.36**
Pension contribution	437	0.0044	0.0071	0.0016	350	0.008	0.015	0.003	−4.67***	−3.97***
Underfund	437	0.785	0.411	1.000	350	0.854	0.353	1.000	−2.50**	n/a
ΔGDP	437	0.049	0.014	0.047	350	0.050	0.015	0.051	−0.54	−0.28
SOX	437	0.535	0.499	1.000	350	1.000	0.000	1.000	−17.40***	n/a
Net PP&E	437	0.261	0.209	0.220	350	0.248	0.202	0.184	0.84	0.92
Zmijewski's score	379	−2.827	1.467	−2.993	322	−2.917	1.548	−3.213	0.79	−1.88*
Dividend cut	437	0.130	0.337	0.000	350	0.117	0.322	0.000	0.56	n/a

In Panel B we also observe an increase in credit risk following DB-plan freezes, as captured by a decrease in median credit ratings and increase in median required bond yields. In addition, we observe an increase in the employer contribution to the firms' pension plans, but at the same time there is an increase in the percentage of pension plans that are underfunded in the post-freeze period.

5. Multivariate analyses

5.1. Determinants of defined benefit plan freezes

While the main objective of this paper is to examine the change in firms' risk and strategies after DB-plan freezes, the decision to freeze a DB plan is not random. The freezing decision can be triggered by macroeconomic changes, new legislation, changes in the firm's operating environment, and the funding status of pension plans. These same factors can also lead to changes in firm risk and business strategies. Therefore, we follow the Heckman (1976) two-stage estimation procedure to adjust for this selection bias. In the first stage, we analyze the determinants of a firm's decision to freeze its DB plan using a modified version of the model proposed by Comprix and Muller (2011). Specifically, we include the change in the dividend payout, leverage, and investment policies in the period prior to the pension freeze decision in the model to examine the lead-lag relationship between the change in policies and the pension freeze decision:

$$\begin{aligned} Freeze = {} & \alpha + \beta_1 Underfund + \beta_2 Funding\% + \beta_3 Firm\ \ Size + \beta_4 Plan\ Size \\ & + \beta_5 Operating\ Cash\ Flow + \beta_6 Loss + \beta_7 \Delta Sales\% + \beta_8 \Delta Dividend \\ & + \beta_9 \Delta Leverage + \beta_{10} \Delta R\&D + \beta_{11} \Delta Capex + \beta_{12} Union\ Plan + \varepsilon \end{aligned} \quad (1)$$

Freeze is an indicator variable equal to one in any year in which the firm's DB plans are frozen, and zero otherwise. *Underfund* is an indicator variable equal to one if the fair value of the plan assets is less than the projected benefit obligation and zero otherwise. *Funding%* is the percentage the pension plan is funded and is computed as the pension plan assets divided by the projected benefit obligation. *Firm Size* is the natural logarithm of total assets. *Plan Size* is the projected benefit obligation divided by total assets. *Operating Cash Flow* is cash flow from operations scaled by total assets. *Loss* is an indicator variable equal to one if the firm reported a loss in the prior year, and zero otherwise. Δ*Sales%* is the percentage change in sales. Δ*Dividend* is the change in dividend payout in the prior year. Δ*Leverage* is the change in debt to asset ratio in the prior year. Δ*R&D* is the change in research and development expense (R&D) to asset ratio in the prior year. Δ*Capex* is the change in capital expenditure to asset ratio in the prior year. *Union Plan* is an indicator variable equals to one if the firm's DB plans are subject to a collective-bargaining agreement, and zero otherwise. We also include year fixed effects to control for the effect of changes in macroeconomic or industry conditions and new legislation on pension freeze decisions.

We estimate Eq. (1) using probit regression analysis, and a sample of annual observations for freezing and non-freezing firms from 1999 to 2009 (see Table 1, Panel A). The results are provided in Table 2. Our estimated coefficients have the same signs as those in Comprix and Muller (2011), except for *Loss. Loss* does not have any significant effect on the freezing decision in our sample but has a significantly positive impact in Comprix and Muller (2011). The difference may be attributable to the different sample period used in the two studies. We observe that large firms and firms with large pension plans are less likely to freeze their plans in our sample period, possibly because of the greater resistance they face when there are more employees affected. The change in investing or financing policies in the prior year does not have any significant impact on the pension freeze decision.

We use the first-stage regression in Table 2 to compute the inverse Mills ratio (Greene, 2008; p. 866). We include these ratios in the second-stage regression analyses of change in firm risk, financial, and operating strategies to control for the endogeneity of the DB-plan freeze decision. One wrinkle is that some of those analyses are conducted using annual data and some using data observed at the quarterly frequency. To resolve this frequency mismatch, for the quarterly regressions we set the inverse Mills ratio equal (to the annual value from Table 2) for all four quarters of the year.

5.2. Changes in firm risk

5.2.1. Total firm risk

To determine if there is a change in total firm risk following DB-plan freezes, we first examine OLS regressions explaining the volatility of earnings (i.e., the volatility of accounting returns). We measure fundamental firm earnings using EBITDA scaled by total assets and return on assets (ROA), and the dependent variable is the logarithm of the quarterly standard deviation of these accounting return measures. Standard deviations are measured over a period of 12 lagged quarters. The independent variable of interest is an indicator variable for the post-freeze period, and we control for other variables that have been shown in the literature to affect earnings volatility. Importantly, we include as an independent variable the *inverse Mills ratio* (*IMR*) calculated from the first stage probit analysis in Eq. (1). We include in the analysis only those firms that have imposed a DB-plan freeze during our sample period. We exclude from our analysis observations from the pension freeze year and the year after, because the computation of standard deviation for these two years includes earnings from the pre-freeze period.[14]

[14] In theory, we should also exclude observations in the second year after DB-plan freezes because the computation of standard deviations of EBITDA or ROA potentially includes EBITDA or ROA from the pension freeze year (because we do not know when the pension freeze is implemented during the year).

Table 2
Determinants of pension freezes.

This table presents results of a probit regression examining a firm's decision to freeze its DB pension plan. We adopt the Comprix and Muller (2011) model in estimating a firm's decision to freeze its DB plans. Because characteristics of pensions are mostly available on an annual basis, the regression uses annual data. The dependent variable, *Post-freeze*, is an indicator variable that equals one if the observation is from a year after the firm freezes its DB plan, and zero otherwise. All other variables are defined in prior tables. Robust standard errors clustered at the firm level are reported in parentheses. ***, **, or * denotes statistical significance at the 1%, 5%, or 10% level (respectively).

Underfund	0.478
	(0.660)
Funding%	7.959***
	(2.197)
Firm Size	−2.249***
	(0.738)
Plan Size	−5.229
	(3.675)
Operating Cash Flow	−1.590
	(1.738)
Loss	−0.614
	(0.424)
ΔSales%	0.008***
	(0.003)
ΔDividend	0.066
	(0.314)
ΔLeverage	0.731
	(1.606)
ΔR&D	−12.230
	(10.274)
ΔCapex	4.514
	(3.785)
Union Plan	−0.622
	(1.282)
Observations	13,266
Log likelihood	−191.45
p-Value of likelihood ratio test	<0.01

The results are presented in Panel A of Table 3. The standard errors in the regressions are robust to heteroscedasticity and serial correlation, and are clustered at the firm level (since our data is an unbalanced panel). All regressions also contain year-quarter fixed effects to control for the impact of business cycles, macroeconomic conditions, and changes in legislation.

Column (1) presents the results when accounting returns are measured as earnings before interest, tax, depreciation, and amortization (EBITDA) scaled by total assets. Column (2) presents the results when return on assets (ROA) is used to measure accounting returns. *Post-freeze* has positive coefficients in both columns, and the coefficients are significantly different from zero at the 1% level. Hence, we conclude that there is a significant increase in total firm risk after DB-plan freezes, consistent with the incentive hypothesis discussed in Section 3. The results in columns (1) and (2) include observations where data used to estimate the first-stage model and compute the inverse Mills ratios are unavailable. To include these observations with missing inverse Mills ratios, we add an indicator variable, *Miss IMR*, which equals one if the inverse Mills ratio is not available to our second-stage analyses. We also set the inverse Mills ratios to zero for these observations.

Columns (3) and (4) report results when observations with missing inverse Mills ratios are *excluded* from the analyses (but the inverse Mills ratio is still included as an independent variable). While the sample size is naturally smaller in these regressions, *Post-freeze* continues to have a positive coefficient that is significantly different from zero, suggesting that total firm risk (as proxied by the volatility of earnings) increases following DB-plan freeze decisions (and controlling for endogeneity of those decisions).

While we observe an increase in total firm risk following DB-plan freezes, this change might start before the DB-plan freeze and continue after the freeze event. That is, the increase in firm risk may simply be part of a time trend. To alleviate this concern, we replace the *Post-freeze* indicator variable with two sets of indicator variables, *Pre-freeze1* to *Pre-freeze5* and *Post-freeze2* to *Post-freeze5*. *Pre-freeze1* equals one if the observation is from the year before the pension freeze, and zero otherwise. *Pre-freeze2* to *Pre-freeze5* are defined similarly. *Post-freeze2* takes on a value of one if the observation is from two years after the pension freeze, and zero otherwise. *Post-freeze3* to *Post-freeze5* are defined in the same way. Similar to the

(*footnote continued*)
However, excluding three yearly observations from our analyses significantly reduces our sample size. Thus, we decide to keep the year $t+2$ observations in our sample. Results excluding $t+2$ are similar to those reported.

Table 3
Earnings volatility following DB-plan freezes.

This table presents results of regressions explaining changes in the standard deviation of earnings (i.e., earnings volatility) following DB pension plan freezes. In Panel A, columns (1) and (2) present results when observations without the required data for the first-stage analysis (Table 2) are included in the regression, while columns (3) and (4) provide the results when these observations are excluded. The dependent variable in columns (1) and (3) of Panel A is the logarithm of *Std EBITDA*; in columns (2) and (4) the dependent variable is the logarithm of *Std ROA*. Observations from the pension freeze year and the year after the pension freeze are excluded from the analyses because the computation of the standard deviation in those two years includes observations from the pre-freeze periods. Panel B presents results based on a sample with the required data for the first-stage probit analysis only, but the results are robust to including observations without the inverse Mills ratios (as in columns (1) and (2) of Panel A). The dependent variable in Panel B is the logarithm of *Std EBITDA*. *Pre-freeze1*, *Pre-freeze2*, *Pre-freeze3*, *Pre-freeze4*, *Pre-freeze5* are indicator variables that equal 1 if the observation is from one year, two years, …, five years before the pension freeze, and zero otherwise. *Post-freeze2*, *Post-freeze3*, *Post-freeze4*, *Post-freeze5* are indicator variables that equal one if the observation is from two years, …, five years after the firm freezes its DB plan, and zero otherwise. *Post-freeze* is an indicator variable that equals one if the observation is from a quarter after the firm freezes its DB plan, and zero otherwise. *Inverse Mills ratio* is computed using the first-stage regression reported in Table 2, used to account for the endogeneity of the pension freeze decision. *Miss IMR* is an indicator variable that takes on a value of 1 if the inverse Mills ratio cannot be computed for the observation because data required for the first-stage regression are missing, and zero otherwise. If *Miss IMR*=1, then *Inverse Mills ratio*=0. All other variables are defined in prior tables, and are from the fiscal quarter ending immediately prior to the quarter in which standard deviations are measured. All regressions contain year-quarter fixed effects, and robust standard errors clustered at the firm level (in parentheses). ***, **, or * denotes statistical significance at the 1%, 5%, or 10% level (respectively).

Panel A. Earnings volatility

	(1) *Log[Std(EBITDA)]*	(2) *Log[Std(ROA)]*	(3) *Log[Std(EBITDA)]*	(4) *Log[Std(ROA)]*
Post-freeze	0.876***	1.103***	0.969***	1.052***
	(0.208)	(0.331)	(0.237)	(0.354)
Log(Sales)	−0.051*	−0.084**	−0.094**	−0.119**
	(0.030)	(0.039)	(0.043)	(0.051)
Sales growth	0.010	0.003	0.092**	0.113**
	(0.006)	(0.006)	(0.043)	(0.053)
M/B (assets)	0.015	0.027	0.043	0.048
	(0.044)	(0.049)	(0.045)	(0.067)
ROA	−0.002	−0.002	−0.003	−0.003
	(0.006)	(0.011)	(0.006)	(0.012)
Leverage	−0.000*	−0.000	−0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
R&D	−0.000	0.000	0.048**	0.026
	(0.001)	(0.001)	(0.019)	(0.040)
Capex	−0.008	−0.000	−0.005	−0.005
	(0.010)	(0.012)	(0.009)	(0.008)
Log(Market capitalization)	−0.001**	−0.002**	−0.001*	−0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
SOX	0.018	−1.852	−1.200***	−0.392
	(1.658)	(5.097)	(0.284)	(0.274)
Inverse Mills ratio	0.099	−0.082	0.144	0.117
	(0.119)	(0.193)	(0.109)	(0.150)
Miss IMR	−0.206	−0.794		
	(0.413)	(0.668)		
Intercept	2.057	−3.197	−4.341***	−3.980***
	(15.823)	(18.843)	(0.548)	(0.704)
Observations	1,639	1,990	1,295	1,574
Adjusted *R*-squared	0.204	0.138	0.222	0.128

Panel B. Trend analysis

Log(Sales)	−0.096**
	(0.044)
Sales growth	0.093**
	(0.043)
M/B (assets)	0.031
	(0.045)
ROA	−0.005
	(0.006)
Leverage	−0.000
	(0.000)
R&D	0.044**
	(0.020)
Capex	−0.007
	(0.010)
Log(Market capitalization)	−0.001*
	(0.001)
SOX	−0.650**
	(0.252)

Table 3 (*continued*)

Panel B. Trend analysis	
Inverse Mills ratio	0.159
	(0.112)
Pre-freeze1	−0.717**
	(0.296)
Pre-freeze2	−0.564**
	(0.279)
Pre-freeze3	−0.462*
	(0.245)
Pre-freeze4	−0.299
	(0.249)
Pre-freeze5	−0.327
	(0.243)
Post-freeze2	−0.095
	(0.210)
Post-freeze3	−0.034
	(0.228)
Post-freeze4	0.324*
	(0.175)
Post-freeze5	0.562***
	(0.196)
Intercept	−4.118***
	(0.566)
Observations	1,295
Adjusted *R*-squared	0.239

analyses in Panel A, we exclude the pension freeze year and the year after from our analysis because the computation of firm risk in these two years involve observations from the pre-freeze period.

The results are presented in Panel B of Table 3, and suggest that total firm risk *decreases* gradually in the pre-freeze period. The coefficient on *Pre-freeze5* is −0.33 and is not significantly different from zero, whereas the coefficient on *Pre-freeze1* is −0.72 and is significantly different from zero at the 5% level. On the other hand, firm risk *increases* following DB-plan freezes. The coefficients on the post-freeze indicator variables gradually increase from −0.10 (p-value of 0.651) on *Post-freeze2* to 0.56 (p-value of 0.005) on *Post-freeze5*. This gradual decrease in firm risk in the pre-freeze period and increase in the post-freeze period is inconsistent with the argument that the increase in firm risk is caused by a time trend that started before the DB-plan freeze (and that freeze coincidentally happens to be in the middle of). Rather, these results support the argument that management deliberately increases risk-taking after DB-plan freezes.

As a robustness test for the increase in total firm risk that we observe using the volatility of accounting returns, we examine the asset (or unlevered) betas of the firms in our sample before and after the freeze event. Specifically, we estimate the firms' equity betas at the quarterly frequency using a market model estimated with daily stock returns. The market model uses exactly the same data that we use to calculate stock return volatility: daily stock returns for the 20 calendar quarters (i.e., five years) before and after the pension freeze year, excluding the freeze year itself. We use the CRSP value-weighted index as a proxy for the overall market.

We then apply the seminal equation from Hamada (1972) to estimate asset/unlevered betas for the firms in our sample.[15] Because this technique removes the effect of the firm's capital structure on estimates of systematic risk, the resulting beta estimates should capture the overall risk of the firm's assets. To implement the Hamada equation, we estimate the firm's debt-to-equity ratio (the book value of debt to the market value of common equity) and effective tax rate, both estimated using Compustat data for the fiscal quarter ending immediately prior to the quarter during which the equity beta is estimated. We also winsorize all variables (equity beta, tax rates, and debt-to-equity ratios) at the 1st/99th percentiles.

We observe an increase in asset betas in the post-freeze period at both the mean and median, consistent with our conclusion from Table 3 that the volatility of accounting returns increases (all else equal) following the freeze of a DB pension plan. Specifically, mean (median) estimated asset betas are 0.62 (0.59) before the freeze events and 0.86 (0.87) after. This increase in asset beta, somewhat crudely capturing the underlying business risk of the firm, is economically large and statistically significant: both differences (in mean and median) are significant at the 1% level. These results are consistent with our conclusion (from Table 3) that firms increase risk-taking after DB-plan freezes.

5.2.2. Equity risk

After observing an increase in total firm risk using the volatility of earnings, we examine whether there is consequent changes in riskiness of the firms' equity and/or debt securities. To investigate the change in risk of equity, we use regressions

[15] We make the standard assumption that the beta of debt is zero.

Table 4
Change in stock-return volatility following DB-plan freezes.

This table presents the results from regressions explaining the change in stock-return volatility following DB pension plan freezes. Columns (1) and (3) present results when observations without the required data for the first-stage analysis (Table 2) are included in the regression, while columns (2) and (4) provide the results when these observations are excluded. The dependent variable in columns (1) and (2) is the logarithm of *Std excess returns*; in columns (3) and (4) the dependent variable is the logarithm of *Std abnormal returns*. The regressions include at most 20 quarterly observations for each freezing firm in the pre- and post-freeze periods, respectively, and observations from the freeze year are excluded. *Post-freeze* is an indicator variable that equals one if the observation is from a quarter after the firm freezes its DB plan, and zero otherwise. All other variables are defined in prior tables, and are from the fiscal quarter ending immediately prior to the quarter in which return standard deviations are measured. All regressions contain year-quarter fixed effects, and robust standard errors clustered at the firm level (in parentheses). ***, **, or * denotes statistical significance at the 1%, 5%, or 10% level (respectively).

	(1)	(2)	(3)	(4)
	Log(Std excess returns)		*Log(Std abnormal returns)*	
Post-freeze	0.273***	0.220***	0.281***	0.222***
	(0.071)	(0.070)	(0.072)	(0.070)
Log(Sales)	0.062**	0.053*	0.068**	0.068***
	(0.030)	(0.030)	(0.031)	(0.029)
M/B (assets)	0.075***	0.051	0.084***	0.089*
	(0.021)	(0.054)	(0.021)	(0.048)
ROA	−3.926***	−3.915***	−4.042***	−3.970***
	(0.426)	(0.482)	(0.444)	(0.503)
Leverage	0.070	0.151	0.098	0.143
	(0.159)	(0.146)	(0.159)	(0.148)
R&D	4.364**	4.515	4.011*	3.897
	(2.167)	(2.816)	(2.047)	(2.661)
Capex	0.003	0.003	0.003	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
Log(Market value of equity)	−0.155***	−0.152***	−0.189***	−0.202***
	(0.026)	(0.030)	(0.027)	(0.030)
Inverse Mills ratio	−0.105*	−0.118**	−0.107*	−0.133**
	(0.053)	(0.055)	(0.054)	(0.059)
Miss IMR	−0.348**		−0.348**	
	(0.165)		(0.171)	
Intercept	−2.800***	−2.614***	−2.727***	−2.337***
	(0.182)	(0.252)	(0.199)	(0.289)
Observations	2,339	1,586	2,339	1,586
Adjusted *R*-squared	0.504	0.510	0.533	0.540

similar to those in Table 3, however the dependent variable is the logarithm of the quarterly standard deviation of daily excess stock returns, *Log(Std excess returns)* (as defined in the previous section and in Table 1). We also run the same regression with (the logarithm of) the quarterly standard deviation of daily *abnormal* returns (also defined in the previous section) as the dependent variable to assess the impact of DB-plan freezes on idiosyncratic risk (i.e., net of market movements). All accounting data used in the analyses are from Compustat for the fiscal quarter that ends immediately prior to the beginning of the calendar quarter (typically the prior day).[16]

The results from these regressions are presented in Table 4, and we use the same techniques as in Table 3 to account for observations with missing inverse Mills ratios. In columns (1) and (2) the dependent variable is (the logarithm of) the quarterly standard deviation of daily excess returns, and the *Post-freeze* indicator variable has a positive and significant coefficient in both columns. Since we omit the entire freeze year from our analysis and examine quarterly volatility (of daily returns) over as much as five years per firm, our results represent long-run changes in risk and, therefore, our results are consistent with operational changes that firms make following DB-plan freezes which increase risk. Such operational changes are potentially prompted by the reduction in “inside debt,” the reduction of which unambiguously aligns senior executives' incentives more closely with those of shareholders (as opposed to debtholders). Hence, we conclude that there is a significant increase in total firm risk after DB-plan freezes, consistent with the results in Table 3 and the incentive hypothesis discussed earlier.

Columns (3) and (4) contain regressions where the dependent variable is the (natural log of) idiosyncratic volatility. The coefficients on the post-freeze indicator variable are very similar to those in columns (1) and (2), and are positive and significant at the 1% level. Coefficients on the control variables are also similar in sign and magnitude to those in the total risk regressions. Overall, our conclusions are little changed when considering idiosyncratic versus total equity risk.

The coefficients on the control variables in Table 4 are largely consistent with prior literature. Using regressions similar to ours, Bushee and Noe (2000), Coles et al. (2006), and Low (2009) all find significant relations between return volatility and size, market-to-book, R&D, and ROA, with the same signs as in Table 4. The one difference with prior literature is that the

[16] The end of the fiscal quarter corresponds to the end of the calendar quarter for the vast majority of the firms in our sample.

Table 5
Change in credit ratings and bond yields following DB-plan freezes.

This table presents results of regressions explaining the change in bond-risk proxies (ratings and yields) after DB pension plan freezes. In Panel A the dependent variable is *Credit rating*. In Panel B the dependent variable is the logarithm of *Yield (%)*. Column (1) in Panel A [columns (1) and (2) in Panel B] presents results when observations without the required data for the first-stage analysis (Table 2) are included in the regression, while column (2) in Panel A [columns (3) and (4) in Panel B] provide the results when these observations are excluded. *Post-freeze* is an indicator variable that equals one if the observation is from a quarter after the firm freezes its DB plan, and zero otherwise. All other variables are defined in prior tables, and are from the fiscal quarter ending immediately prior to the quarter in which credit ratings or bond yields are measured. All regressions contain year-quarter fixed effects, and robust standard errors (in parentheses). ***, **, or * denotes statistical significance at the 1%, 5%, or 10% level (respectively).

Panel A. Credit ratings

	(1)	(2)
Post-freeze	−0.029**	−0.021*
	(0.013)	(0.013)
Firm Size	0.057***	0.060***
	(0.015)	(0.018)
Underfund	0.008	0.060**
	(0.018)	(0.027)
Std(ROA)	−0.093	−0.050
	(0.074)	(0.050)
Times interest earned	−0.001***	−0.001
	(0.000)	(0.001)
Sales growth	0.030	−0.012
	(0.033)	(0.020)
Leverage (debt)	−0.049	−0.042
	(0.051)	(0.047)
SOX	−0.015	−0.018
	(0.013)	(0.012)
Inverse Mills ratio	0.027	0.080**
	(0.021)	(0.031)
Miss IMR	0.128*	
	(0.070)	
Intercept	0.048	−0.168
	(0.169)	(0.226)
Observations	452	409
Adjusted *R*-squared	0.173	0.137

Panel B. Bond yields

	(1)	(2)	(3)	(4)
Post-freeze	0.238***	0.591***	0.279***	0.600***
	(0.089)	(0.124)	(0.103)	(0.135)
Debt/equity		0.017		−0.005
		(0.032)		(0.036)
Profit margin		−0.339		−0.688*
		(0.314)		(0.355)
Times interest earned		0.005		0.019***
		(0.004)		(0.005)
Log(Market value of equity)		−0.230***		−0.283***
		(0.033)		(0.038)
Subordinated		−0.287***		−0.269***
		(0.035)		(0.039)
Log(Maturity)		−0.069		−0.099*
		(0.051)		(0.059)
Log(Treasury bond yield)		0.204*		0.339**
		(0.112)		(0.141)
Log(Premium on AAA bonds)		0.553		0.724
		(1.448)		(1.769)
Inverse Mills ratio	−0.188**	−0.323***	−0.200**	−0.423***
	(0.081)	(0.109)	(0.086)	(0.118)
Miss IMR	−0.694***	−1.362***		
	(0.225)	(0.311)		
Intercept	2.210***	4.552***	2.218***	5.211***
	(0.220)	(0.603)	(0.235)	(0.713)
Observations	1,208	834	963	700
Adjusted *R*-squared	0.01	0.14	0.01	0.12

existing studies cited above find a strong, positive relation between leverage and stock return volatility. While the coefficient on the leverage variable in Table 4 is positive, it is not statistically significant at traditional levels.

5.2.3. Credit risk

In addition to the change in the volatility of stock returns, a change in firm risk may also be reflected in changes in its credit rating and yields on publicly traded bonds. There can be an increase in default risk because of the higher overall firm risk. This increase in default risk may lead to a decrease in credit rating and an increase in yield demanded by bondholders. Thus, we examine whether there is a decrease in credit rating and an increase in bond yields after a firm freezes its DB plan by comparing the S&P credit ratings and yields on publicly traded bonds issued by our sample firms in the pre- versus post-freeze periods. The credit rating analysis is performed on an annual basis because S&P credit rating data are not available at shorter frequencies. There is a significant drop in our sample size for the bond-yield analyses because not all sample firms have the required bond trading data: we measure average traded bond yields for 44 out of our 116 sample firms. The calculation of trade-size weighted average yields (the dependent variable) is described in Section 4.

Our results are presented in Table 5. Panel A reports the results for credit ratings and Panel B provides those for bond yields. *Post-freeze* has a significantly negative coefficient in Panel A, suggesting that a firm's credit rating drops on average by about two-third of a grade after it imposes DB-plan freeze.[17] This provides further support for the incentive hypothesis: an increase in overall risk-taking appears to lead to an increase in default risk, consistent with the observed increase in equity risk and overall firm risk.

We further investigate the change in default risk by examining (the natural logarithm of) bond yields on the firms' publicly-traded bonds in Panel B. *Post-freeze* has a significantly positive coefficient in all columns, with the most conservative of those coefficients (0.238 in column (1)) suggesting that yields on traded bonds increase by an average of 1.27 percentage points (i.e., $\exp(0.238)=1.27$) following a DB-plan freeze. Given that the average bond yield in our sample is 18.68%, this increase in the post-freeze period represents a 6.8% change in average bond yields. Hence, the increase in bond yield is both statistically and economically significant.

In column (2), we repeat the analyses controlling for other factors that may have an impact on the bond yield. We include the debt to market value of equity ratio to account for the effect of leverage, a proxy for default risk, on bond yields. We also include the times interest earned ratio to control for a firm's ability to meet interest payments. We control for the effect of firm size and specific characteristics of the bond issued, such as its maturity and whether it is a subordinated bond, in our analysis. Lastly, we control for the yield of a Treasury security with a corresponding term to maturity and the premium of AAA bonds over treasuries. After controlling for these factors, we continue to observe a statistically and economically significant increase in bond yields after DB-plan freeze events. Columns (3) and (4) report the results when observations without the inverse Mills ratios from the first-stage probit analysis (Table 2) are excluded from the bond yield regressions, and the coefficients on the post-freeze indicator variables are qualitatively identical to those in columns (1) and (2). Overall, the results in Table 5 suggest a significant increase in default risk and deterioration of credit quality following DB-plan freezes, indicated by both declining credit ratings and increasing yields on traded bonds.

In summary, in Tables 3 to 5 we find that, controlling for a large number of potential covariates, firm risk *increases* significantly following freezes of DB pension plans, as reflected in crediting ratings, bond yields, and the volatility of stock and accounting returns (earnings). In the next section we explore the operational and financial changes in firm structure that might be responsible for the marked increase in risk following DB-plan freezes.

5.3. Operational and financial changes in risk-taking activities

The above results suggest that there is an increase in firm risk after DB-plan freezes, reflected in earnings volatility and metrics from the firms' publicly traded securities (debt and equity). In this section, we investigate potential causes of this increase in risk. Specifically, we examine whether there are significant changes in investment, financing, and operating strategies that might expose the firm to greater risk.

We examine changes between the pre-freeze and post-freeze periods in investment, both capital expenditure and research and development (R&D). We also examine the effect on firm leverage, and operational concentration. We measure the latter construct using the firms' segment Herfindahl index, computed as the sum of the squares of the ratio of segment sales divided by firm sales, with higher values indicating more concentrated (or focused) firms. All the model specifications include the inverse Mills ratios from the first-stage regression to control for the endogeneity of the DB-plan freeze decision and firm fixed effects to address potential omitted firm characteristics that may impact these strategies.

Most of the control variables are similar to those described in the previous section, except measured at the annual (rather than quarterly) frequency. The additional control variables used in this part of the analysis include *Std(ROA)* (the standard deviation of ROA in the prior three years), *Sales growth* (growth in sales from year $t-2$ to $t-1$), *Net PP&E* (investment in property, plant and equipment scaled by total assets), *Zmijewski score* (Zmijewski's *Z*-score[18] to capture the probability

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[17] We convert the letter grade of S&P credit rating into numerical values by assigning a value of 1 to a firm with an AAA rating. The difference between each grade (i.e., between AAA and AA+) is about 0.045 (=1/22, since there are 22 ratings grades).

[18] $Zmijewski's\ Z\text{-}score = -4.336 - 4.513 \times ROA + 5.679 \times Leverage + 0.004 \times Liquidity$.

Table 6
The impact of DB-plan freezes on investment.

This table presents results of regressions explaining the change in firms' investment activities (Capex and R&D) after DB pension plan freezes. Columns (1) and (2) present results when observations without the required data for the first-stage analysis (Table 2) are included in the regression, while columns (3) and (4) provide the results when these observations are excluded. *Post-freeze* is an indicator variable that equals one if the observation is from a year after the firm freezes its DB plan, and zero otherwise. All other variables are defined in prior tables, and all continuous variables are adjusted for the industry/year mean. All regressions contain firm fixed effects, and robust standard errors clustered at the firm level (in parentheses). ***, **, or * denotes statistical significance at the 1%, 5%, or 10% level (respectively).

	(1) Capex	(2) R&D	(3) Capex	(4) R&D
Post-freeze	−0.223**	0.211***	−0.141	0.242***
	(0.102)	(0.058)	(0.124)	(0.065)
ROA	−0.000	0.000	−0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Total assets	−0.159	0.002	−0.126	−0.003
	(0.104)	(0.038)	(0.088)	(0.039)
Sales growth	0.018**	−0.008***	0.016**	−0.007***
	(0.007)	(0.002)	(0.007)	(0.002)
Std(ROA)	−0.002**	−0.000	−0.002***	−0.000
	(0.001)	(0.000)	(0.000)	(0.000)
M/B (assets)	0.000	−0.000	0.001	0.000
	(0.001)	(0.000)	(0.001)	(0.000)
Leverage	0.122	0.063***	0.109	0.076***
	(0.081)	(0.017)	(0.095)	(0.026)
Non-pension cash flows	0.011**	−0.008*	0.013*	−0.012
	(0.005)	(0.005)	(0.007)	(0.009)
Pension contribution	−2.371	0.942	−4.817*	0.475
	(4.021)	(1.179)	(2.842)	(1.223)
Underfund	−0.114	0.030	−0.036	0.045
	(0.146)	(0.050)	(0.090)	(0.057)
%ΔGDP	−1.199	−0.708	0.808	−0.196
	(1.982)	(0.865)	(1.937)	(0.993)
SOX	0.084	−0.144***	0.037	−0.199***
	(0.111)	(0.052)	(0.081)	(0.066)
Inverse Mills ratio	−0.036	0.059	0.020	0.037
	(0.111)	(0.061)	(0.076)	(0.071)
Miss IMR	−0.642	0.176		
	(0.454)	(0.190)		
Intercept	0.258	−0.342	−0.154	−0.304
	(0.392)	(0.215)	(0.331)	(0.255)
Observations	763	786	606	607
Adjusted *R*-squared	0.063	0.082	0.093	0.101

of bankruptcy), *Dividend cut* (an indicator variable that assumes a value of one if the firm lowers its dividend in the year, and zero otherwise), *Non-pension cash flows* (cash flow excluding the pension contribution) and *Pension contribution*. An indicator variable for the funding status of the pension plan (*Underfund*) is also included as a control variable, as is a variable (*%ΔGDP*) intended to capture the effect of macro-economy on investment, financing, and operation strategies. We also include a *SOX* indicator variable to capture any effect the Sarbanes-Oxley Act might have on firm strategies.

Table 6 reports the results of our regressions examining the effect of DB-plan freezes on investment strategies, while Table 7 reports the effect on financing and operating strategies. The results in column (1) of Table 6 suggest that there is a decrease in net capital expenditure in the post-freeze period (coefficient of *Post-freeze* = −0.22, significant at the 5% level) after controlling for other potential determinants of capital expenditures. On the other hand, DB-plan freezes have a positive effect on R&D expenditures. The coefficient on *Post-freeze* in column (2) is 0.21 and is statistically significant at the 1% level. Taken together, these results suggest that firms shift from less risky capital expenditure investments to more risky research and development projects following DB-plan freezes (Coles et al., 2006; Bhagat and Welch, 1995; Kothari et al., 2002). This is consistent with the increase in firm risk observed in Tables 3 through 5. These results support the contention that there is a shift in investment strategy after a firm freezes its DB pension plan, and in particular an increase in the firm's willingness to take on higher risk projects (consistent with the realignment of managerial incentives).

When we compare financing strategies in the period before a firm freezes its DB plan versus the period after the freeze, we observe a significant increase in debt financing.[19] The coefficient on *Post-freeze* in column (1) of Table 7 (the leverage

[19] The results reported in Table 7 are based on the book leverage (total debt divided by book value of total assets). We have repeated the analysis using market leverage (total debt divided by the sum of the market value of equity and the book value of debt) and the results are qualitatively similar. The drop in sample size for the leverage analysis is largely caused by missing data for lagged Zmijewski score, whereas the drop in the sample size for the segment Herfindahl index analysis is caused by missing segment data for some firms.

Table 7
The impact of DB-plan freezes on financing and operational strategies.

This table presents results of regressions explaining the change in firms' financing and operational strategies in the post-freeze period. Columns (1) and (2) present results when observations without the required data for the first-stage analysis (Table 2) are included in the regression, while columns (3) and (4) provide the results when these observations are excluded. *Post-freeze* is an indicator variable that equals one if the observation is from a year after the firm freezes its DB plan, and zero otherwise. All other variables are defined in prior tables, and all continuous variables are adjusted for the industry/year mean. All regressions contain firm fixed effects, and robust standard errors clustered at the firm level (in parentheses). ***, **, or * denotes statistical significance at the 1%, 5%, or 10% level (respectively).

	(1) Leverage	(2) Segment Herfindahl	(3) Leverage	(4) Segment Herfindahl
Post-freeze	0.199*	6.196	0.231*	−1.725
	(0.105)	(16.933)	(0.133)	(20.624)
ROA	0.000	0.124	0.000	0.118
	(0.000)	(0.149)	(0.000)	(0.145)
Total assets	0.170*	−174.372	0.238**	−206.773
	(0.101)	(168.125)	(0.112)	(200.498)
Sales growth	0.017*	−0.138	0.015	−0.152
	(0.010)	(0.250)	(0.009)	(0.320)
Std(ROA)	0.001	−6.172**	0.001	−6.823***
	(0.002)	(2.639)	(0.002)	(2.424)
M/B (assets)	0.011***	−0.409	0.012*	−0.618
	(0.004)	(0.373)	(0.006)	(0.625)
Leverage		−4.375		−6.126
		(4.148)		(6.251)
R&D	−0.195**		−0.109	
	(0.095)		(0.125)	
Net PP&E	−0.067**		−0.047**	
	(0.031)		(0.021)	
Zmijewski score	−0.003		−0.002	
	(0.002)		(0.002)	
Dividend cut		33.863		48.955
		(41.215)		(56.820)
Non-pension cash flows	0.015*	0.309	0.025	1.213
	(0.009)	(1.161)	(0.017)	(2.480)
Pension contribution	4.122	436.485	5.007	392.547
	(6.315)	(523.461)	(6.103)	(660.723)
Underfund	−0.052	−6.179	−0.143	−8.859
	(0.169)	(10.952)	(0.207)	(16.123)
%ΔGDP	1.012	−1,542.784	0.940	−1,670.870
	(3.007)	(1,622.037)	(3.414)	(1,801.472)
SOX	−0.104	−55.251	−0.227	−67.608
	(0.172)	(47.265)	(0.177)	(56.476)
Inverse Mills ratio	0.338**	0.666	0.788	−1.679
	(0.151)	(17.912)	(0.546)	(22.491)
Miss IMR	1.375***	35.283		
	(0.495)	(78.741)		
Intercept	−1.802***	45.007	−1.037**	41.475
	(0.513)	(83.881)	(0.464)	(107.487)
Observations	700	516	566	437
Adjusted R-squared	0.201	0.037	0.167	0.045

regression) is 0.20 and is statistically significant at the 10% level.[20] Lastly, we investigate the change in operating strategy following DB-plan freezes. We use the segment Herfindahl index (computed using segment sales) to measure concentration or focus: the higher the Herfindahl index, the more focused a firm's business is. In column (2) of Table 7 we do not observe any significant change in the segment Herfindahl index after a firm imposes a DB pension freeze. The coefficient on *Post-freeze* is positive but insignificant.[21] Columns (3) and (4) present very similar results using only the observations for which there are enough data to calculate the inverse Mills ratio in the first-stage regression.

Overall, the results in Tables 6 and 7 suggest that firms are more willing to take on risky investment and financing strategies after they implement DB-plan freezes: leverage appears to increase, and investment appears to shift from capital expenditures to R&D. We do not, however, observe any increase in operational focus.

[20] The coefficient on the market-to-book is positive in the regression in column (1) of Table 7, which uses industry-adjusted data. When we use raw data in our regression (i.e., without industry adjustment), the coefficient on firm market-to-book becomes negative, consistent with the prior literature.

[21] We have also performed the analysis using the number of business or operating segments of each firm as the dependent variable and the coefficient of *Post-freeze* remains insignificant.

6. Sensitivity analyses

6.1. Funding status

In the regressions in Tables 6 and 7, we pooled together all firms that have a DB-plan freeze between 2002 and 2007, without considering the funding status of the plan before the freeze (which may impact investment or leverage). We repeat the analyses after including a control variable for the plan's funding status, *Pre_Underfund*, two years before the freeze. This variable takes on a value of one if the DB plan was underfunded two years prior to the DB-plan freeze decision, and zero otherwise. We also include the interaction with *Post-freeze* to investigate whether the change in financing or investment activities after a freeze is affected by funding status before the freeze.

In all our regressions, none of the coefficients of *Pre_Underfund* or its interaction with *Post-freeze* is statistically significant, indicating that changes in a firm's investing and financing strategies in the post-DB-plan-freeze period are not affected by the funding status of its pension plan before the freeze. This alleviates some of the concern that our observed changes in financial strategy (e.g., more leverage) are dictated by financial constraints as opposed to deliberate changes in risk-taking by management. We have repeated this sensitivity analysis using the variable *Underfund* (an indicator variable taking on a value of one if the pension fund was underfunded in the year before the DB-plan freeze, and zero otherwise) and its interaction with *Post-freeze*, and the results are qualitatively the same as those using *Pre_Underfund*.

6.2. Additional control variables

Firms undergoing management changes likely modify their strategies, policies, and, potentially, pension plans. To control for the effect of this possible contemporaneous event, we include an indicator variable, ΔCEO, which equals one if there is a change in CEO and zero otherwise, in our first- and second-stage analyses. We also include an interaction term between ΔCEO and *Post-freeze* in the second-stage analyses to capture any differential effect DB-plan freezes have on firms who also undergo change in top management. Our results are similar to those reported in Tables 3 through 7. Specifically, *Post-freeze* has a positive impact on risk, R&D investment, and leverage, and a negative effect on net capital expenditure. ΔCEO and its interaction with *Post-freeze* are not significantly different from zero at the 10% level.

In addition to controlling for CEO changes, we also repeat our analyses after controlling for the CEO's length of service. The length of service can affect management's risk-taking incentives because the longer the service period, the higher the accumulated pension benefits, and the greater the inside debt incentives (and the longer it takes for those to reduce in importance after the freeze event). Management with high inside debt incentives are likely more reluctant to take on risky projects which can jeopardize their retirement benefits. We control for the CEO's tenure and the number of years credited in the retirement plan to capture the length of service. The tenor of our results remains unchanged. Also, the coefficients on CEO tenure and the years credited are not significantly different from zero in any of the regressions replicating Tables 3–7.

Management's incentives to take on risky projects can also be affected by their equity-based compensation. Firms grant equity-based compensation (stock options and restricted stock) to management in order to better align their risk-taking incentives with those of shareholders. In order to control for possible equity-based compensation effects on management's business strategies, we include the change in equity-based compensation in our model specifications. This results in a significant reduction in our sample size, because we cannot obtain the necessary compensation data for a large portion of our sample firms. For this reduced sample, we continue to observe an increase in overall firm risk, increased investment in R&D, and higher leverage in the post-DB-plan freeze period.[22]

6.3. Propensity-score matching

In addition to the Heckman two-stage estimation procedure, we also use the propensity-scoring matching method (Rosenbaum and Rubin, 1983) to identify a matched sample of firms who have not frozen their DB plans to adjust for the endogenous nature of the DB-plan freeze decision. Specifically, we estimate Eq. (1) for all firms with the required financial and pension data in Compustat and on Form 5500 to compute their propensity to freeze DB plans in a year. For each firm that freezes its DB plan during our sample period, we then select another firm that has not frozen its DB plan and has the closest propensity score (predicted from Eq. (1)) to our DB-plan freeze firm. We match using the propensity score in the year of DB-plan freeze. According to the Comprix and Muller (2011) DB-plan freeze model, this firm is close to being as likely to freeze its DB plan as the freezing firm was in that year. By comparing the change in firm risk, investment, and financial strategies between the two firms (one of which experiences a "pseudo post-freeze period" because they do not actually freeze their DB pension plan), we might be able to minimize the spurious effect of factors driving both the DB-freeze decision and the change in strategies.

[22] Only 390 out of the 1,295 sample observations in the overall firm risk analysis have equity compensation data. For the capital expenditure analysis, the sample size drops from 763 to 270 observations; for the R&D analysis, sample size decreases from 786 observations to 282; for the financing regression, sample size declines from 700 to 254 observations; for the operational strategy analysis, sample size drops from 516 to 226 observations. Results from regression analyses using these smaller samples are qualitatively similar to those documented in Tables 3–7, except for the capital expenditure analysis. In that regression the coefficient on *Post-freeze* becomes insignificantly different from zero.

In regressions similar to those presented in Tables 3–7, but including indicator variables and interaction terms to isolate the "placebo" effect for the matched firms, the majority of results presented in Section 5 continue to hold, and, importantly, are observed *only* for our DB-plan freeze firms but not the matched firms. For the sake of brevity, these results are not tabulated (but are available from the authors by request). Specifically, the following findings hold *only* for freeze firms in the period following DB-plan freezes and not their matches: earnings volatility rises (Table 3), credit ratings fall with a corresponding increase in bond yields (Table 5), and firms shift their investment from capital expenditures to R&D (Table 6) and increase their leverage (Table 7). While we observe an increase in stock return volatility (Table 4) following DB-plan freezes for both freeze firms and their matches, the increase in return volatility is statistically much greater for the freezing firms than for their matches (potentially suggesting that the results in Table 4 are directionally correct but their magnitude may be overstated). In general, these results further support the argument that DB-plan freezes provide management with incentives to take on more risk by changing their investment and financing strategies.

7. Conclusion

This paper examines the impact of freezing a defined benefit pension plan on firms' risk and risk-taking activities (investment, financing, and operational strategies). Based on a sample of firms that report a hard freeze of their DB plans during the period 2002–2007, we observe an increase in total firm risk after DB-plan freezes. An examination of the change in equity and credit risk suggests that such increases are reflected in the prices of the firms' publicly traded securities.

When we compare the investment strategies of these firms in the pre- versus post-freeze periods, we observe a substantial increase in investment in higher risk research and development projects, while investment in less risky capital expenditure projects declines. Similarly, there is an increase in the use of leverage following DB-plan freezes. These investment and financing strategic changes all induce higher risk, consistent with our findings about credit ratings, bond yields, accounting-return volatility, and stock-return volatility. These results are robust to the various methods used to control for the endogeneity of the DB-plan freeze decision and the inclusion of CEO change, equity-based compensation, CEO tenure and years credited in the retirement plan, and the funding status of the pension plans in our analyses.

We argue that these results are most consistent with the incentive effect of freezing a DB plan. Freezing a DB pension plan may have two, potentially offsetting effects: the direct effect of lowering risk (because firms formerly sponsoring DB plans no longer have to guarantee the payout of a specific amount of benefits) and the incentive effect induced by the fact that inside debt positions are less important in shaping incentives when DB pension plans are frozen. Therefore, our results suggest that managers' incentives are aligned with stockholders' to a greater extent, and with bondholders' to a lesser extent (because of the reduction in inside debt), following defined benefit pension plan freezes.

References

Amit, R., Livnat, J., 1988. Diversification strategies, business cycles, and economic performance. Strategic Manage. J. 9, 99–110.

Anantharaman, D., Fang, V., Gong, G., 2011. Inside debt and the design of corporate debt contracts. Working paper. Rutgers University and Pennsylvania State University.

Aon Consulting, 2003. Aon Study: Pension Plan Freezes Moving to Forefront; More Possible Without Changes to Funding Rules. Press Release.

Atanasova, C.V., Hrazdil, K., 2010. Why do healthy firms freeze their defined benefit pension plans? Global Finance J. 21, 293–303.

Bargeron, L., Lehn, K., Zutter, C., 2010. Sarbanes-Oxley and corporate risk-taking. J. Account. Econ. 49, 34–52.

Bhagat, S., Welch, I., 1995. Corporate research and development investments: international comparisons. J. Account. Econ. 19, 443–470.

Bodie, Z., Light, J.O., Morck, R., Taggart, R.A., 1987. Funding and asset allocation in corporate pension plans: an empirical investigation. Working paper. NBER.

Bodie, Z., Papke, L., 1992. Pension Fund Finance. Pensions and the Economy. University of Pennsylvania Press, Philadelphia, PA149–172.

Broadbent, J., Palumbo, M., Woodman, E., 2006. The Shift From Defined Benefit to Defined Contribution Pension Plans—Implications for Asset Allocation and Risk Management. Prepared for a Working Group on Institutional Investors: Global Savings and Asset Allocation; Established by the Committee on the Global Financial System.

Bushee, B.J., Noe, C.F., 2000. Corporate disclosure practice, institutional investors, and stock return volatility. J. Account. Res. 38, 171–202.

Byrnes, N., 2006. The Rush to Shut Down Pensions. Business Week, New York, NY.

Campbell, J.Y., Lettau, M., Malkiel, B.G., Xu, Y., 2001. Have individual stocks become more volatile? An empirical exploration of idiosyncratic risk. J. Financ. 56, 1–43.

Coles, J.L., Daniel, N.D., Naveen, L., 2006. Managerial incentives and risk-taking. J. Financ. Econ. 79, 431–468.

Comment, R., Jarrell, G.A., 1995. Corporate focus and stock returns. J. Financ. Econ. 37, 67–87.

Comprix, J., Muller, K., 2011. Pension plan accounting estimates and the freezing of defined benefit pension plans. J. Account. Econ. 51, 115–133.

Employee Retirement Income Security Act of 1974 (ERISA). Pub. L. No. 93-406. Codified in Part at 29 USCS § 1002 *et seq*.

Edmans, A., Liu, Q., 2011. Inside debt. Rev. Financ. 15, 75–102.

Feldstein, M., Seligman, S., 1981. Pension funding, share prices, and national savings. J. Financ. 36, 801–825.

Feldstein, M. and Morck, R., 1983. Pension funding decisions, interest rate assumptions and share price. Financial Aspects of the United States Pension System, University of Chicago Press, Chicago, IL, pp. 177-210.

Greene, W., 2008. Econometric Analysis. Pearson Prentice Hall, Upper Saddle River, NJ.

Hamada, R., 1972. The effect of the firm's capital structure on the systematic risk of common stocks. J. Financ. 27, 435–452.

Heckman, J., 1976. The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. Ann. Econ. Soc. Measure. 5, 475–492.

Hewitt Associates, 2006. Survey Findings: Hot Topics in Retirement, 2006. Hewitt Associates, Lincolnshire, IL.

Kieso, D.E., Weygandt, J.J., Warfield, T.D., 2010. Intermediate Accountingfourteenth ed John Wiley and Sons Inc., NJ.

Kothari, S.P., Laguerre, T.E., Leone, A.J., 2002. Capitalization versus expensing: evidence on the uncertainty of future earnings from capital expenditures versus R&D outlays. Rev. Account. Stud. 7, 355–382.

Lang, L.H.P., Stulz, R.M., 1994. Tobin's q, corporate diversification, and firm performance. J. Polit. Econ. 102, 1248–1280.

Low, A., 2009. Managerial risk-taking behavior and equity-based compensation. J. Financ. Econ. 92, 470–490.

McFarland, B., Pang, G., Warshawsky, M., 2009. Does freezing a defined-benefit pension plan increase company value? Empirical evidence. Financ. Anal. J. 65, 47–59.
Milevsky, M.A., Song, K., 2010. Do markets like frozen DB pensions? An event study. J. Risk Insurance 77, 893–909.
Mercer Human Resource Consulting, 2006. A Closer Look at Recent High Profile Pension Plan Freezes. Update. New York.
Munnell, A.H., Golub-Sass, F., Soto, M., Vitagliano, F., 2007. Why are Healthy Employers Freezing Their Pensions? Issue in Brief no. 44. Boston College Center for Retirement Research.
Munnell, A.H., Soto, M., 2004. The outlook for pension contributions and profits in the U.S. J. Pension Econ. Financ. 3, 77–97.
Munnell, A., Sunden, A., 2004. Coming Up Short: The Challenge of 401(k) Plans. Brookings Institution Press, Washington, DC.
Nadel, A.A., Nager, R.W., 1992. Avoiding Excise Tax on Keogh Plan Reversions. The Tax Adviser. November 1. ⟨http://www.allbusiness.com/personal-finance/individual-taxes/331691-1.html⟩.
Oldfield, G.S., 1977. Financial aspects of the private pension system. J. Money, Credit Bank. 1, 48–54.
Petersen, M., 1992. Pension reversions and worker-stockholder wealth transfers. Q. J. Econ. 107, 1033–1059.
Pricewaterhouse Coopers, 2005. Employers express strong concerns over cost volatility of defined benefit pension plans, Management Barometer.
Private Pension Plan Bulletin, 2008. U.S. Department of Labor Employee Benefits Security Administration. February.
Rauh, J.D., 2006. Investment and financing constraints: evidence from the funding of corporate pension plans. J. Financ. 36, 33–71.
Rosenbaum, P., Rubin, D., 1983. The central role of the propensity score in observational studies for causal effects. Biometrika 70, 41–55.
Schrager, A., 2006. A life-cycle analysis of the decline of defined benefit plans and job tenure. Working paper. Columbia University.
Sundaram, R.K., Yermack, D.L., 2007. Pay me later: inside debt and its role in managerial compensation. J. Financ. 62, 1551–1588.
Watson, Wyatt, 2007. Pension Freezes: Has the Worst Passed? Insider (September).
Watson, Wyatt, 2010. Pension Freezes Continue Among Fortune 1000 Companies in 2010. Insider (September).
Wei, C., Yermack, D., 2011. Investor reactions to CEOs' inside debt incentives. Rev. Financ. Stud 24, 3813–3840.
Wernerfelt, B., Montgomery, C.A., 1988. Tobin's q and the importance of focus in firm performance. Am. Econ. Rev. 78, 246–250.