

The Impact of Pension Obligations on Firm Decisions

by

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ABSTRACT

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Employer-sponsored defined benefit pensions are declining in popularity, yet these long-term obligations will influence firm decisions for decades to come. The first chapter models how the tax and other incentives posed by sponsoring a defined benefit pension interact with traditional moral hazard between stockholders and bondholders. While the contracting problems associated with each may be manageable, moral hazards arising from investment risk and from contributing to a pension plan together lead to first-order distortions. The second chapter describes how this dynamic leads to higher borrowing rates among firms with defined benefit pensions. Like traditional corporate bonds, pension debt is a long-term liability that influences default risk and firm value – two important determinants of bond spreads. Yet pension debt magnifies default risk stemming from agency problems, implying that a ten percentage point increase in unfunded pension liabilities raises defined benefit firms' bond spreads by 23 basis points, while an equivalent increase in standard external leverage increases bond spreads by only 2.6 basis points.

Finally, the third chapter looks at how sponsoring a defined benefit pension influenced firm performance in the Great Recession. Many firms with defined benefit pensions experienced dramatic losses in the value of pension assets between 2007 and 2009 that led to high required pension payments. A general concern was that those payments prevented firms from making productive investments that could assist economic recovery. This paper suggests, instead, that pension losses allowed firms to borrow from their pensioners, while the credit crunch prevented those firms from taking on sub-optimally high leverage ratios and investment risk that are usually motivated by costly pensions. Indeed, firms making minimum required contributions from 2000 through 2007 supported leverage ratios that were 4.6 percentage points higher and default premiums that were 22 percent higher than their counterparts with less costly pensions. This wedge did not exist during the Great Recession.

CHAPTER 1

Pension Obligations, Firm Borrowing and Investment Risk

Employer-sponsored defined benefit pensions are declining in popularity, yet these long-term obligations will influence firm decisions for decades to come. This paper builds a new model to describe how the tax, regulatory, and investment incentives created by sponsoring a defined benefit pension interact with traditional moral hazard between stockholders and bondholders. While the contracting problems associated with each may be manageable, moral hazards arising from investment risk and from contributing to a pension plan together lead to first-order distortions.

1.1 Introduction

Defined benefit pensions sponsored by private employers account for 2.5 percent (\$3 trillion) of total domestic financial assets in the U.S. economy, belying their reputation as lost to the mists of time. Firms that sponsor defined benefit pensions manage unfunded pension liabilities, a type of debt unavailable to firms without pensions. Existing theory implies that pension debt and external debt are substitutes with similar impacts on investment decisions (Treynor, 1977; Sharpe, 1979). Yet this theory ignores important regulatory and investment incentives facing firms that sponsor defined benefit pensions. Explicitly accounting for these incentives suggests that pension debt and external debt may, in fact, be complements, and that sponsoring a defined benefit pension encourages some firms to borrow more and make riskier investments.

This result stems from a new model of firms' financing and investment decisions when they sponsor defined benefit pensions. The model explicitly accounts for the interaction between regulations facing firms that sponsor defined benefit pensions and conflicts of interest among stockholders, bondholders, and pensioners. Facing full information, limited liability, and non-contractible risk in production, a defined benefit firm raises external debt (bonds) and equity in competitive markets in the first period and allocates its operating funds across production, pension contributions, and a safe asset in the second period to maximize returns to its shareholders. A firm can "borrow" from its pensioners by making smaller pension contributions than required to maintain a fully funded pension account. Given the model timing, there is a contracting problem between the borrower (firm) and its lenders (bondholders and pensioners): the firm is unable to commit itself to a complete state-contingent set of investment restrictions. With substantial operating funds in the second period, the firm will make investments that are more risky than in the interest of its lenders.

Bondholders and pensioners manage this contracting problem differently. Bondholders set borrowing premia that reflect the cost of the overly-risky investments the firm would make so that, in expectation, they recoup the opportunity cost of the funds they lend. Pensioners, on the other hand, limit the extent of pension debt with minimum funding requirements and depend on a government-sponsored insurance agency to provide payments if the firm enters bankruptcy with an underfunded pension account. Neither the minimum funding requirement nor the insurance premium depend on the firms' profile of investment risk. This highlights the key difference between external and pension debt: unlike external debt, pension debt payments are determined independently of the additional investment risk the firm imposes on its lenders. While the firm pays the agency cost associated with

the risk it imposes on its bondholders through higher borrowing premia, it does not pay the agency cost it imposes on its pensioners. In this way, the interaction between pension regulations and conflicts of interest among stakeholders provides the firm a source of financing – pension debt – that does not internalize the consequences of overly-risky investments.

This unique characteristic of pension debt increases both the costs and benefits of external debt. Defined-benefit firms that borrow from pensioners avoid paying the full agency cost associated with non-contractible production risk. Bondholders have full information and are aware that these firms, as a result, may make even riskier investments. Accordingly, bondholders charge higher borrowing premia to firms that face the incentive to make riskier investments: sponsoring a defined benefit pension can make external debt more expensive. Yet bondholders share bankruptcy liability with pensioners and, therefore, do not raise premiums enough to reflect the full agency cost of non-contractible production risk. This encourages the firm to take on more pension debt, the full cost of which it avoids in bankruptcy. The possibility of avoiding pension costs in bankruptcy, in turn, encourages the firm to assume higher bankruptcy risk and, thus, higher levels of external debt. In this way, sponsoring a defined benefit pension can make external debt more attractive.

As a result of this dynamic, defined benefit firms may face a different optimal capital structure and investment profile than firms without pensions. The firm's incentive to take on additional external debt is proportional to the firm's pension debt: more pension liabilities can be offloaded in bankruptcy. Similarly, the firm's incentive to make riskier investments is also proportional to the firm's pension debt: higher pension debt implies the firm pays a lower portion of the agency cost associated with investment risk. Accordingly, defined-benefit firms with large unfunded pension liabilities take on more external debt, make riskier investment decisions, and pay higher bond premiums. On the other hand, under-funding a pension account, or taking on pension debt, is associated with regulatory fees that are large when the pension account is less funded. Therefore, a defined benefit firm faces a trade-off when making its financing decision: it could take on more external debt and contribute more to its pension, but make riskier investments and face higher bond premiums; or it could constrain the amount of external debt it takes on and make fewer risky investments, but contribute less to the pension account and face higher regulatory pension fees. When making its financing decision, the firm compares potential agency costs determined by the production risk it faces and regulatory pension fees determined by its current level of pension funding.

In explicitly modeling the role of the interaction between pension regulations and conflicts of interest among stakeholders in firms' financing, investment and pension funding decisions, this paper explores a new dimension of the risk associated with sponsoring a de-

defined benefit pension. Previous models of pension obligations envision pension liabilities analogously to external debt: put options with longer maturities (Treynor, 1977; Sharpe, 1976). Unlike the model proposed here, in which pension and external debt are intertwined, unfunded pension obligations function as a type of debt that is independent from external borrowing. These existing models imply that pension debt and external debt are substitutes that should be priced the same. The empirical evidence testing this prediction is mixed: early work suggests that pension liabilities are appropriately priced (Black, 1981; Feldstein and Seligman, 1980), while more recent work suggests that they are mis-priced (Gold, 2005; Coronado et al., 2008). The model presented here suggests a more nuanced empirical relationship among pension debt, external debt and market value of the firm. While pension and external debt may appear to be substitutes at the margin, conflicts of interest among stakeholders encourage firms with more pension debt to take on higher levels of external debt as well. Further, these conflicts of interest can encourage firms with more pension debt to make riskier investments, implying that, empirically, pension debt and external debt may not be similarly priced.

In a nod toward an extensive literature on the tax benefits of debt that arise from the standard corporate interest exemption (Jensen and Meckling, 1976; Miller, 1977; Graham, 2001; Blouin et al., 2010), this paper explicitly models the role of tax treatment of defined benefit pensions in corporate capital structure decisions. Like traditional interest payments, pension contributions and interest earned on pension assets are exempt from the corporate tax. These non-debt tax shields not only encourage higher levels of pension funding but, like investment-tax credits and depreciation deductions, may also lower the tax benefits of debt for firms that sponsor a defined benefit pension (DeAngelo and Masulis, 1980). Indeed, Shivdasani and Stefanescu (2012) estimate that pension-related exemptions decrease the debt conservatism identified in Graham (2000) by nearly one-third. At the same time, this paper highlights that a defined benefit firm pays the magnified agency cost that discourages it from taking on more external debt through interest payments. When those payments are exempt from the corporate tax, higher tax rates will increase the firm's incentive to make risky investments and therefore increase the agency cost associated with debt finance.

This model sheds light on a recent empirical literature that exploits variation in minimum required pension contributions to speak to a long-standing debate on whether an observed correlation between cash-flow and investment levels indicates the presence of financing constraints (Fazzari et. Al, 1988; Kaplan and Zingales, 1997). This literature uses differences in required pension contributions as an instrument for variation in cash-flow. Some of these papers use non-linearities in the formula used to calculate minimum required pension contributions as exogenous variation (Rauh, 2006; Bakke and Whited,

2012), while others use policy changes that decrease the minimum required contribution (Dhambra, 2014; Kubick, et. Al, 2014). Any theoretical model predicting that exogenous changes in cash flow influence firm value requires that firms face a wedge between the internal and external cost of funds. The model presented in this paper shows that the interaction between pension regulation and the stockholder-bondholder conflict can create such a wedge, but then brings into question whether changes in minimum pension contributions – which contribute to the size of that wedge through this mechanism – are valid instruments for cash-flow.

This paper describes the impact of pension regulations and conflicts of interest among stakeholders on financing, investment, and pension funding in four steps. Section 2 describes the regulations facing sponsors of defined benefit pensions with an eye toward how these regulations generate contracting inefficiencies. Section 3 lays out the model environment – an environment in which firms without a pension are indifferent between debt and equity finance. Section 4 explores several nuances of the model solution: defined benefit firms’ financing decisions depend not only on the investment risk they face, but also on regulatory costs associated with their pensions; the conflict of interest between stockholders and bondholders can encourage firms to contribute less to their pensions; unique tax incentives facing firms that sponsor defined benefit pensions can both increase and decrease the tax benefits of external debt; firms face the incentive to invest pension assets in projects correlated with investments held within the firm; and sponsoring a pension can create a wedge between firms’ internal and external cost of funds. Section 5 concludes.

1.2 The Legal Environment

The Employee Retirement Income Security Act (ERISA) and subsequent pension legislation regulates firms sponsoring defined benefit pensions. This regulatory framework includes the Pension Benefit Guarantee Corporation (PBGC), a government-formed entity that insures privately-sponsored defined benefit pensions, and a set of regulations that dictates how a private firm manages its DB pension assets. Under ERISA, assets held in the pension plan face different rules than general assets of the firm.¹ This section discusses four categories in which the rules facing pension and general firm assets differ: pension funding status, required contributions, and premium; investment regulation; tax treatment; and bankruptcy rights. Each subsection describes current regulations of DB sponsors in one of the four categories, considers how those regulations lead to different treatment of funds borrowed from external lenders through loan agreements and funds borrowed from

¹ERISA was enacted in 1974. Major revisions were passed in 1987, 1994, and 2006.

pensioners through pension shortfalls, and previews how the regulations are integrated a model of a defined benefit sponsor's financing, investment, and pension contribution decisions.

1.2.1 Pension funding status, required contributions, and premiums

A pension plan is fully funded when it holds enough assets to cover the present discounted value of accrued pension promises; otherwise, it faces a funding shortfall. Sponsors of under-funded plans are required to make minimum pension contributions that cover newly accrued pension liabilities and amortize any funding shortfall over several years. The amount of the shortfall that must be amortized increases in relation to the percent by which the plan is under-funded.² Firms can request a waiver of the minimum required contribution from the Internal Revenue Service (IRS) when facing extreme financial hardship. The IRS grants such waivers for a maximum of three consecutive years over a fifteen year period. These rules may entice a failing defined benefit firm to consider pensioners as stop-gap lenders: when a firm cannot raise external funds, it can support production by further under-funding its pension and, thus, borrowing from its pensioners.

Defined benefit firms also pay required insurance premiums to the PBGC. All defined benefit firms, regardless of the funding status of their pensions, must pay fixed-rate premiums to the PBGC. This fixed-rate premium is proportional to the number of current and past employees that the plan supports. Firms that sponsor under-funded pensions are also required to pay variable-rate premiums to the PBGC that are proportional to the magnitude of their funding shortfall. These required payments manifest in the model as a regulatory pension cost that is quadratic in the magnitude of the funding shortfall. Firms without a pension deficit face a flat-rate PBGC premium, while firms with a pension deficit face a PBGC premium that increases based on the size of the deficit, implying a higher implicit cost for a larger deficit. The minimum required contribution represents a drain on internal resources when the firm may face more productive investment opportunities. This required payment – and, therefore, the potential drain on resources – is higher as a portion of the funding shortfall when that shortfall is larger.

²Prior to 2006, shortfalls were amortized over 15 years. The Pension Protection Act of 2006 required firms to amortize shortfalls over seven years. Pension funding relief passed in 2010 allowed firms to either waive funding shortfalls for two years and then amortize those shortfalls over seven years (the 7+2 plan), or amortize shortfalls over 15 years (the 15 plan). Pension plans that are over 90 percent funded only amortize a fraction of the funding shortfall. This fraction is larger for plans that are under 80 percent funded and larger yet for plans under 60 percent funded.

1.2.2 Restrictions on investment

Moral hazard between the firm and the pensioner implies that the firm may choose investments, both in the pension account and with general firm assets, with more risk than is in pensioner's interest.³ Federal regulations of DB sponsors restrict the investment allocation of assets held in the pension account, but ignore risk stemming from general firm investments. Pension assets must be held in readily valued investments and no more than 10% of those investments may be in employer stock or securities. These regulations are a step toward discouraging excessive risk taking with pension funds. The baseline model discussed in the next section captures restrictions on pension investments through independent return processes facing production and pension investments.⁴ Further, the regulatory costs of maintaining an under-funded pension do not depend on the production risk the firm assumes in general firm investments.

1.2.3 Tax treatment

Contributions to the pension account and returns earned on pension assets are exempt from the corporate tax. This exemption applies to contributions to and returns on all pension accounts that are less than 150 percent funded.⁵ An excise tax of 50 percent that a firm pays whenever it removes funds from the pension account discourages firms from leaving operating funds to accumulate tax-free in the pension account and extracting them to cover general firm expenses.⁶ The tax break on pension contributions increases the cost to a defined-benefit sponsor of contributing less to an under-funded pension, while the funding limit and excise tax decrease the cost of contributing less to an over-funded pension.

This tax treatment manifests in the model in three ways. First, the tax exemption for pension returns drives a larger wedge between the return on pension assets and return on productive investments: the pension and production return differ not only because pension

³The extension in section 4.4 suggests that this may be the case if pension and production returns are correlated. This is an implication of previous models that focus on the moral hazard between the pensioner and the firm (Sweeting, 2006). Rauh (2009), however, finds that the allocation of pension plans is more likely to be influenced by risk management than this risk exploitation.

⁴Section 4.4 discusses an extension in which the pension and production returns can be correlated. The firm prefers to choose pension investments that are correlated with general firm investments.

⁵Pension liabilities can be calculated in two ways: the projected and accrued liability. The projected liability takes into account future salary increases of covered workers, while the accrued liability does not. The full funding limit for the tax deduction on pension returns and contributions has varied as a portion of these two liabilities over the years. Prior to 1987, the full funding limit was 100% of the projected liability, but was lowered in 1987 to the minimum of 100% of the actuarial liability or 150% of the current liability. This limit was loosened in the early 2000s but currently stands at 150% of the projected liability.

⁶This excise tax was first introduced at 10% in 1986, and increased to 15% in 1988. The current rate of the excise tax, 50%, was set in 1990.

assets cannot be invested in employer stock or securities, but also because pension returns do not face the corporate tax while production returns do. Second, the quadratic form of the regulatory pension cost incorporates the loss of the tax break on pension assets over the full funding limit. It also incorporates solvency costs imposed by holding surplus funds in the pension account where they cannot be easily accessed. Third, a sponsor can only claim a fraction $1 - \chi$ of surplus pension assets. This fraction represents the excise tax and other costs due to terminating the pension plan. A model extension in Section 4.3 explicitly models tax exemptions for pension contributions and traditional interest payments.

1.2.4 Bankruptcy treatment

Because the firm and its pension plan are separate legal entities, treatments of assets held in a pension plan and assets held in a firm differ in bankruptcy. If a defined benefit firm enters a termination bankruptcy with a pension deficit, the PBGC takes over the pension plan: the PBGC appropriates all assets held in the plan and assumes responsibility for paying accrued benefits. The PBGC also tries to claim general firm assets to fill the funding shortfall. Secured creditors receive priority over the PBGC in claiming assets held in the firm, but unsecured creditors and the PBGC vie for the next position in the distribution priority.⁷ If a defined benefit firm nears bankruptcy with a pension surplus, the firm may use surplus assets to repay creditors and avoid bankruptcy. Tapping into these surplus assets requires the firm to terminate the pension plan by purchasing annuities at market price for all accrued pension promises made to pensioners. The firm can then claim any excess assets left in the plan through an asset reversion that faces the 50% excise tax.

The bankruptcy treatment of pension assets and liabilities in the model manifests in the solvency constraint for the firm and the lender's payoff in bankruptcy. A defined benefit firm is solvent if it can make all required payments to the lender using general firm assets and the after-tax portion of pension surplus that can be claimed in an asset reversion. In bankruptcy, the lender receives all general firm assets and the after-tax portion of any reverted pension assets.

⁷The distribution priority in bankruptcy when a firm sponsors an underfunded pension is complicated. Secured creditors are paid back before pensioners, but if the firm has unsecured creditors, it must prove that it has done all in its power to write down unsecured claims before the PBGC will take it over. The "lender" in the model is a secured creditor.

1.3 The Model Environment

This section describes a formal model of the financing, investment, and pension contribution decisions of a defined benefit firm facing non-contractible production risk. In an environment of full information and facing the possibility of limited-liability bankruptcy, the risk-neutral firm raises equity and/or borrows externally to fund risky investment in production, pension contributions, and investment in a safe asset. Three actors influence these decisions: the lender, the shareholders or firm, and a government sponsored insurance agency (the PBGC). The lender determines the conditions of any loan agreement with the firm. Shareholders are passive participants who receive a return on investments held outside of the firm equal to the return on safe assets held within the firm. The firm acts on behalf of its shareholders to maximize their expected payoff. The third actor, the Pension Benefit Guarantee Corporation (PBGC), insures the firm's pension at an exogenous insurance rate.

Three of these modeling choices particularly emphasize the role of the interaction between contracting problems introduced by pension regulations and conflicts of interest between stockholders and bondholders in financing and investment decisions: the static structure of the model, the assumption that the firm maximizes shareholder payoff, and the focus on the PBGC rather than the worker. A static model abstracts from complications related to debt overhang that arise in a dynamic setting. The assumption that the firm maximizes shareholder payoff sidesteps potential conflicts of interest between stockholders and managers.⁸ The focus on the PBGC rather than the worker abstracts from potential wage negotiations between the worker and the firm. This last assumption implies that, prior to the start of the model, workers negotiate a wage that leaves them indifferent between working at a firm that offers a defined benefit pension and one that does not, taking into account potential bankruptcy and PBGC pension coverage. As a result, the model focuses on the financing and investment decisions of the firm, conditional on existing pension liabilities, rather than the impact of pension regulations on employment.

1.3.1 Assumptions

Four sets of assumptions provide the structure of the model: (1) the timing of decisions and knowledge of participants, (2) the purview of the loan agreement to contract upon the sponsor's decisions, (3) the market structure facing the lender and sponsor, and (4) the introduction of the defined benefit pension. The first three sets of assumptions are standard in many models of corporate borrowing, with one deviation: the loan agreement cannot

⁸See Lay (2016)b or Choy et. Al (2014) for a discussion of how moral hazard between the stockholder and manager may influence financing and investment decisions with a defined benefit pension.

contract upon contributions to the pension account. The introduction of the defined benefit pension is laid out in parallel with the description of the regulations facing defined benefit firms laid out in the previous section.

Timing of decisions and knowledge of participants

The model features complete markets, full information, and limited liability in bankruptcy. A firm begins with cash-on-hand X , pension liabilities D , and pension assets P , and faces two risky investment opportunities: production and pension investments. Investing I in production results in output $zf(I)$, where $f(I)$ exhibits decreasing returns to scale and satisfies the Inada Conditions. Productivity $z = z^s$ with probability p or $z = z^F < z^s$ with probability $1 - p$. Contributing C to the pension account yields a constant return $1 + \rho$. Figure 1 describes the model events.

In the first period, the firm raises additional equity E . Knowing the firm's equity stake, the lender offers the firm a schedule of loan agreements that consist of a rate, $\frac{b}{B}$, and amount B , discussed further in the next subsection. The firm decides how much to borrow at the offered rates. In the second period, the firm chooses how much to invest, $I \geq 0$, and contribute to the pension, $C \geq 0$, conditional on the amount of funds – cash, debt, and new equity – it has available, Y . The firm saves any residual funds in a safe asset with return $1 + r$. In the third period, the firm realizes the return on production and the pension account. A firm that does not have enough cash-on-hand to repay the lender will go bankrupt. The lender and shareholders receive their payoffs.

The loan agreement

A loan agreement consists of a loan of size B and an amount b that a solvent firm must repay in period 3. Prior to the loan agreement, the firm raises an observable amount of equity E . Total funds are then distributed across productive investment, pension contributions, and a safe asset. The loan agreement cannot contract upon the distribution of funds across pension contributions and productive investment. This is the key contracting inefficiency that induces moral hazard problems between the stockholder and bondholder: a firm must raise enough funds to contribute to the pension, but cannot credibly commit to its lender that it will avoid over-investing in risky production.⁹

The lender offers two types of loans. The lender offers a safe loan at rate $1 + r$ if the firm has raised enough equity to avoid bankruptcy when production fails. Under a safe

⁹The lack of covenants on investment represents minor non-contractible conflicts of interest between the stockholder and bondholder. Without a pension, the resulting inefficiencies are second-order.

loan, the firm internalizes production losses in all states of the world. The lender offers a risky loan if the firm does not raise enough equity to avoid bankruptcy if production fails. Under a risky loan, the lender specifies a borrowing premium, $b_R > (1 + r)B$, to reflect potential losses it incurs if the firm is insolvent.

The market structure

The lender operates in a competitive market. Therefore, it offers a loan rate $\frac{b}{B}$ such that it breaks-even in expectation, conditional on loan size B and the firm's equity position $X + E$. The lender has an opportunity cost of funds $1 + r$. The firm produces one good and seeks to maximize shareholder payoff. The shareholders' opportunity cost of funds is $1 + r$. The firm is required to pay pension liabilities D in the indefinite future, but this model abstracts from the labor market in which those liabilities are incurred: assume that pensioners negotiated wages and deferred compensation, taking into account the insured value of their pension, prior to model events. The pension insurer, the PBGC, sets an exogenous insurance premium, captured in the regulatory pension cost discussed in following subsections, that depends on the size of the funding shortfall. While a second moral hazard problem exists between the PBGC and the firm, the PBGC does not adjust rates to internalize risky production decisions to the firm.

The defined benefit pension

The firm's possession of a pension plan and its position in that pension plan are both exogenous: the firm begins the first period with an amount of pension liabilities, D , that it must pay in the third period and an amount of dedicated pension assets, P . Three sets of further assumptions integrate this pension plan into the model: (1) the return on assets held in the pension account relative to the returns on production and the safe asset, (2) the conditions that lead to firm bankruptcy, and (3) the payoff functions of the lender and firm.

Returns on the pension, production, and safe asset The firm realizes the stochastic return to its own productivity, $z = z^j$, at the beginning of period 3. The firm also receives its return on the safe asset, $1 + r$, and pension investments, $1 + \rho$. The pension return is independent of the firm's productivity, reflecting the ERISA requirement that limited pension assets can be invested in the firm's own capital stock.¹⁰ The pension return can differ from the return on the safe rate, reflecting the fact that the firm pays the corporate tax

¹⁰Assumption is made for clarity in presenting key results. Appendix C shows solution with stochastic returns that are correlated with investment.

on returns to safe assets held in the firm but avoids the corporate tax on returns to pension assets.¹¹

Bankruptcy condition The firm faces two types of required payments: the debt repayment and required pension payments. ERISA regulations allow a firm to waive required pension payments if making those payments would drive the firm into bankruptcy. Therefore, a firm must repay only the debt to external lenders, b , to avoid bankruptcy in the final period. The firm may use assets held in the firm, but cannot claim funds from a pension that is in deficit to cover required payments and avoid bankruptcy. The firm can claim funds from a pension that is in surplus to avoid bankruptcy. However, this asset reversion incurs a cost, χ , proportional to the amount of funds reverted. Let $1 - \chi^k = 0$ if the pension is in deficit when the firm contributes C and pension return ρ is realized, and $\chi^k = \chi \in [0, 1]$ if the pension is in surplus.¹² The firm remains solvent if:

$$\underbrace{z^j f(I) + (1+r)(B + X + \underline{E} - I - C)}_{\text{Assets held within the firm}} + \underbrace{(1 - \chi^k)[(1 + \rho)(P + C) - D]}_{\text{Pension assets that could be used to cover required payments}} \geq \underbrace{b}_{\text{Required payment to lender}} \quad (1.1)$$

Lender and firm payoff The lender and firm payoffs in period 3 reflect regulatory treatment of pension assets and contributions. The lender sets the required equity and borrowing premium according to its expected period 3 payoff, viewed in period 1. The firm allocates funds across investment and contributions to maximize its expected period 3 payoff, viewed in period 2. Prior to this allocation decision, the firm determines financing to maximize its expected period 3 payoff viewed in period 1. These expected payoffs are built from realized payoffs in period 3.

¹¹While the baseline model abstracts from its effects, section 4.3 presents an extension examining the effects of the corporate tax. For this section, suppose $1 + r$ is the after-tax return on safe assets, like treasuries, and $1 + \rho$ is the pre-tax return on assets held in the pension account. The tax deduction is one factor that drives the pension return above the safe rate.

¹²As in section 2, firms with a surplus can terminate the pension and revert surplus funds, taxed at 50%, to prevent bankruptcy. χ reflects this tax and any other termination fees. Accordingly, assume $\chi > .5$.

The lender's payoff Let W^j be the lender's payoff in period 3 when $z = z^j$ is the realization of productivity.

$$W^j = \begin{cases} b & \text{If firm is solvent} \\ \underbrace{\max\{z^j f(I) + (1+r)(B+X+\underline{E}-I-C), 0\}}_{\text{Profits held within firm}} + \underbrace{(1-\chi^k)[(1+\rho)(P+C)-D]}_{\text{Potential claimable pension assets}} & \text{If the firm is insolvent} \end{cases} \quad (1.2)$$

Note that both I and C depend on the firm's total funds in period 2, $B + X + \underline{E}$, and the required repayment amount b . When the firm is solvent, lenders receive the agreed-upon repayment amount b . When the firm is insolvent, lenders have rights to all assets held within the firm and partial rights to excess pension assets held in over-funded pensions. These rights do not extend to pension assets held in under-funded pensions. If a defined benefit sponsor goes bankrupt with its pension in deficit, the PBGC assumes the plan assets and liabilities.¹³

A lender that invests an amount B in safe assets receives a certain payment of $(1+r)B$ in period 3. Upon request for a loan of size B , the lender will offer a safe agreement with $b_S = (1+r)B$ if the firm has raised enough equity to avoid bankruptcy. The lender will offer a risky agreement in which it chooses a borrowing premium $b_R > (1+r)B$ if the firm has not raised enough equity to avoid bankruptcy. In each type of agreement, the choice of b is made so that the lender breaks-even, or receives $(1+r)B$ in expectation. The lender's expected period-3 payoff, viewed in period 1, from offering a loan of size B at rate $\frac{b}{B}$ is:¹⁴

$$\mathbb{E}_1(W(b|B, E)) = pW^S + (1-p)W^F$$

¹³In takeovers, the PBGC assumes assets held in the plan and responsibility for paying pensioners. Pensioners owed benefits from severely under-funded plans taken over by the PBGC receive, on average, $\frac{2}{3}$ of promised payments.

¹⁴ I and C are determined as a function of $B + X + \underline{E}$ and b , therefore $\mathbb{E}_1(W(b, E|B))$ is known in period 1.

The firm's payoff Let V^j be the firm's payoff in period 3 when productivity $z = z^j$ is realized.

$$V^j = \begin{cases} \underbrace{z^j f(I) + (1+r)(B+X+E-I-C) - b}_{\text{Profits held in firm}} \\ + \underbrace{[(1+\rho)(P+C) - D]}_{\text{Surplus or deficit in pension}} - \underbrace{\frac{\mu}{2} [(1+\rho)(P+C) - D]^2}_{\text{Regulatory pension cost}} \\ \text{If the firm is solvent} \\ 0 \\ \text{If firm is insolvent} \end{cases} \quad (1.3)$$

Equation 1.3 captures four components of the sponsor's payoff: limited liability, profits from production, pension surplus or deficit, and regulatory costs of sponsoring a pension. Limited liability is evident in the asymmetric payoff function: the shareholders of an insolvent firm receive nothing but do not repay debts. Profits from production held within the firm increase the payoff to the shareholders of a solvent firm (first term in equation 1.3). A pension surplus will increase the payoff to the shareholders of a solvent firm, while a pension deficit will decrease their payoff (second term in equation 1.3). Note that the firm, responsible for future pension contributions and maintenance, pays the pension deficit and associated regulatory costs when it avoids bankruptcy. This encourages the firm to take on more debt and risk bankruptcy. The regulatory costs of sponsoring a pension, the third term in equation 1.3, require a more detailed explanation.

Figure 1.2 provides an example of the payoff a firm receives in the final period from its pension upon realizing pension return ρ , as a function of its contribution in the second period, C . If pension assets and firm assets received equal regulatory treatment, the marginal return to the firm of a pension contribution of one dollar would be $1 + \rho$. However, regulations imply that the firm faces a marginal return on pension contributions that varies according to the period-3 funding status of the plan. To interpret Figure 1.2, suppose that the variable-rate component of the PBGC premium is ϕ – that is, any firm holding a pension shortfall must pay a fraction ϕ of that shortfall to the PBGC as an insurance premium – and the corporate tax rate is τ . Further, suppose that the firm began the first period with pension assets P and liabilities D , that imply a funding shortfall, $P < D$.

Suppose the firm contributed an amount C – along the horizontal axis in figure 1.2a – in the second period, and realized a pension return $1 + \rho$ in the third period. Further, suppose that the original funding status of the plan was such that $P(1 + \rho) < D$: if the firm did not contribute to the pension account in the second period ($C = 0$), it faces a pension deficit

in the third period, pays the variable-rate PBGC premium, and receives a payoff from its pension of $((1 + \rho)P - D)(1 - \phi)$. In the figure, suppose that a second-period contribution of size C_0 will lead to an exactly funded pension plan when return $1 + \rho$ is realized, while a contribution of size C^H will lead to a pension account that is 150% funded when return $1 + \rho$ is realized. A pension contribution less than C_0 results in an under-funded pension in the third period, while a pension contribution greater than C^H results in a pension that is over-funded to the point of losing the tax deduction on pension returns.

The marginal return to the pension contribution varies by the size of the contribution. The marginal return to a pension contribution $C \in (0, C_0)$ in Figure 1.2a results in a pension deficit and will be higher than $1 + \rho$: by contributing another dollar to the pension account, the firm not only receives the investment return ρ , but also decreases the realized pension deficit by $1 + \rho$. As a result, the PBGC insurance premium, proportional to the funding shortfall, will decrease by $\phi(1 + \rho)$. The marginal return to a pension contribution $C \in (C_0, C^H)$, on the other hand, results in a pension plan that is between 100 and 150 percent funded and will be lower than $1 + \rho$: fees associated with reverting surplus pension assets will leave the firm only $(1 - \chi)(1 + \rho)$ for each dollar contributed to the pension. Finally, a contribution of size $C > C^H$ results in a pension surplus over 150 percent, and will face a marginal return lower than $1 + \rho$ for two reasons: (1) the firm can only claim a fraction $1 - \chi$ of surplus assets, and (2) the return on pension assets held in an account over 150 percent funded is not sheltered from corporate taxes. Therefore, the marginal return to $C > C^H$ is $(1 - \tau)(1 - \chi)(1 + \rho)$.

In Figure 1.2b, this nonlinear payoff structure is approximated as the sum of the pension surplus and a quadratic ‘regulatory pension cost’. The quadratic regulatory cost is a second-order approximation of a variety of loss functions that take into account other regulatory costs beyond those direct costs described in Figure 1.2a. A firm that sponsors an under-funded pension, for example, makes minimum required contributions that are an increasing portion of the size of the pension shortfall. This required contribution represents an indirect cost of the pension account because it exerts an inflexible demand on cash-flow at a time when other investments may provide higher return. The parameter μ in Figure 1.2b captures how important these indirect costs are to the firm; suppose μ decreases in firm size: when required contributions or insolvent pension assets are smaller relative to total firm assets, their impact on the firm’s payoff is smaller.

The firm makes two decisions in this model: it borrows and raises equity in period 1 and allocates funds across investment and pension contributions in period 2. Since the firm makes the allocation decision taking B , \underline{E} , and b as given, I and C can be considered functions of these variables. The payoff function that the sponsor consults when solving its

allocation problem is:

$$\mathbb{E}_2(V(I, C|B, \underline{E}, b)) = pV^S + (1 - p)V^F$$

With I and C functions of the loan agreement and financing decision, the sponsor's expected payoff viewed in period 1 can be expressed as a function of B , \underline{E} , and b :

$$\mathbb{E}_1(V(B, E|\underline{E}, b)) = pV^S + (1 - p)V^F$$

1.3.2 Definition of an Equilibrium

An equilibrium in this model is an arrangement in which the DB sponsor chooses a financing position (B^*, E^*) and an allocation of funds (I^*, C^*) . These decisions jointly maximize the sponsor's payoff, and the lender expects to break-even under the required loan agreement $(b^*|B^*, E^*)$.

Definition An equilibrium consists of a financing position $\mathcal{F} = (B^*, E^*)$, a loan agreement $\mathcal{L}^* = (b^*|B^*, E^*)$, and an allocation decision $\mathcal{A} = (I^*, C^*)$ such that:

1. Conditional on \mathcal{L}^* and \mathcal{A}^* , the financing position \mathcal{F}^* maximizes the firm's expected payoff viewed in period 1:

$$(B^*, E^*) = \arg \max_{(B, E)} \mathbb{E}_1(V(E, B|b^*, I^*, C^*)) \quad (1.4)$$

2. Conditional on \mathcal{L}^* and \mathcal{F}^* , the allocation decision \mathcal{A}^* maximizes the firm's expected payoff viewed in period 2:

$$(I^*, C^*) = \arg \max_{(I, C)} \mathbb{E}_2(V(I, C|B^*, E^*, b^*))$$

subject to (1.5)

$$I^* + C^* \leq B^* + X + E^*$$

3. Conditional on \mathcal{F}^* and \mathcal{A}^* , the loan agreement \mathcal{L}^* allows the lender to break-even in expectation:

$$(1 + r)B^* = \mathbb{E}_1(W(b^*|B^*, E^*, I^*, C^*)) \quad (1.6)$$

Note that a firm may endogenously choose to limit its period 2 operating funds in the first period when the production risk a firm faces – and, therefore, it's borrowing premium

– is high enough that the firm chooses to limit its borrowing. This will lower its productive investment and pension contributions.

1.4 The Model Solution

The model solution consists of three decisions of the lender and firm: the lender’s loan offering, the firm’s allocation decision, and the firm’s financing decision. The main section discusses the model solution in parallel with these decisions, with the full analytic solution to this model presented in Appendix A. The following subsections suggest a quantitative interpretation of five analytic results: how a firm chooses financing, the impact of the stockholder-bondholder conflict on pension funding, the influence of the tax benefits of debt on defined benefit firms’ financing and investment decisions, the attractiveness of alternative investment strategies in the pension account, and the impact of exogenous financing constraints on the investment and pension contributions of a firm sponsoring a defined benefit pension.

The Loan Agreement The lender observes the equity the firm raises in the first period and, with full information, predicts the level of investment and contributions the firm will choose when it borrows an amount B . The lender offers loans at rates that allow it to break even, in expectation. When the firm has raised enough equity to avoid bankruptcy, the lender sets required repayment $b_S(B|E) = (1+r)B$. When the firm has not raised enough equity to avoid bankruptcy, the lender sets required repayment $b_R(B|E)$:

$$\begin{aligned}
 b_R(B|E) = & \underbrace{(1+r)B}_{\substack{\text{Opportunity cost} \\ \text{of the lender}}} \\
 & + \frac{1-p}{p} \left\{ \underbrace{(1+r)(I-X-E) - z^F f(I)}_{\text{Standard premium without pension}} + \underbrace{(1+r)C - \mathbb{E}(\chi S|C)}_{\text{Premium due to pension}} \right\}
 \end{aligned} \tag{1.7}$$

As in standard models of corporate borrowing, the borrowing premium decreases when the firm holds more collateral, $X + E$, or faces less production risk (higher z^F). Sponsoring a pension increases the premium when the expected contribution is non-zero and the pension faces a small expected surplus or an expected deficit.

The Allocation Decision The firm chooses how much to invest and contribute in the second period. In period 2, the firm has operating funds, $Y = B + E + X$, and faces a required repayment $b(B|E)$. Due to contracting inefficiencies that prevent the firm from

committing to a complete state-contingent set of investment restrictions, the firm views Y and b as given when allocating funds across investment, contributions, and the safe asset. Figure 1.3 describes this allocation decision when the firm saves in the safe asset: investments in the safe asset receive marginal return $1 + r$, and the firm chooses investment and contributions so that their expected marginal returns are also equal to $1 + r$. The firm that raised enough equity in the first period to avoid bankruptcy faces an expected payoff from investing I of $\mathbb{E}(z)f(I)$. The firm that did not raise enough equity in the first period to avoid bankruptcy faces an expected payoff from investing I when it remains solvent of $z^s f(I)$. Therefore, the firm that avoids bankruptcy invests at the social optimum I_S^* in Figure 1.3, where $\mathbb{E}(z)f'(I_S^*) = 1 + r$. The firm that faces possible bankruptcy – and moral hazard with lender – over-invests in risky production, choosing $I = I_R^*$ so that $z^s f'(I_R^*) = 1 + r$. Both firms face the same expected return from the pension: pension and production returns are independent, and the firm goes bankrupt only if production fails. As a result, firms that face moral hazard with the lender choose the same pension contribution as firms that do not. In Figure 1.3, that contribution, \bar{C} , is the firm’s optimal contribution under current pension regulations.

Figure 1.4 describes the optimal allocations under a safe and risky agreement when the firm raised fewer operating funds in the first period: $Y < I_S^* + \bar{C}$. With constrained operating funds, the firm does not save in the safe asset. It chooses investment and contributions so that their marginal returns are equal, but higher than $1 + r$. The resulting investment and contribution are lower than the allocation in Figure 1.3. When the firm faces possible bankruptcy, the expected return from investment relative to pension contributions is higher than when it does not face bankruptcy. As a result, the firm invests more relative to contributions when it finances primarily with debt than when it raises substantial equity: moral hazard with the lender encourages the firm to invest more at the expense of pensioners when it is financially constrained.

The financing decision The firm’s financing decision in the first period selects whether the equilibrium dynamics of Figure 1.3 or those of Figure 1.4 determine investment and contributions in the second period. In choosing how much equity to raise, the firm determines whether it faces possible bankruptcy – that is, whether it faces moral hazard with the lender. In choosing how much to borrow, the firm determines whether it has enough money to save in the safe asset, and invest and contribute according to the dynamics in Figure 1.3, or whether it invests and contributes under the constrained dynamics in Figure 1.4.

Figure 1.5 describes three potential equilibrium financing decisions. First, the firm could raise enough equity to avoid bankruptcy (Position S1 in Figure 1.5). As a re-

sult, the firm avoids moral hazard with the lender, and raises enough operating funds to save in the safe asset, invest at the social optimum, and contribute at the firm's optimum: $(I, C) = (I_S^*, \bar{C})$. Alternatively, the firm could choose to raise less equity and risk possible bankruptcy. As a result, the firm faces moral hazard with the lender and internalizes the cost of that moral hazard through a higher borrowing rate. Facing possible bankruptcy, the firm chooses one of two financing positions: it borrows enough to over-invest in risky production and contribute optimally to its pension account, Position R1: $(I^*, C^*) = (I_R^*, \bar{C})$, or it constrains its borrowing so that it invests less in risky production and under-contributes to its pension plan, Position R2: $(I^*, C^*) = (I_R^* - \Delta I, \bar{C} - \Delta C)$. Each of these three financing positions is associated with a different cost to the firm: Position S1 requires the firm to service the pension regardless of production performance; Position R1 requires the firm to pay the social cost of over-investment in risky production through a higher borrowing rate; and Position R2 requires the firm to pay the regulatory penalty associated with under-contributing to the pension account. The firm chooses the financing position that is associated with the lowest cost.

1.4.1 What makes defined benefit firms prefer debt or equity finance?

Firms prefer debt finance when the pension costs avoided in bankruptcy are high relative to the costs of over-investment or under-contributing to the pension account. Firms prefer equity finance when the pension cost avoided in bankruptcy is low relative to these other costs.

Sponsoring a defined benefit pension imposes substantial future costs on the firm. When the plan is fully funded, the firm faces maintenance costs, investment risk, and the inability to use the funds in that account for more productive purposes. When the plan is in deficit, the firm must also make future pension contributions. A firm that avoids bankruptcy by raising substantial equity will always pay this pension cost; a firm that finances with debt avoids this pension cost in bankruptcy. Therefore, the cost associated with financing position S1 in Figure 1.5 is the pension cost the firm would avoid if it went bankrupt when

production failed:

$$\begin{aligned}
 \underbrace{\text{Expected avoided pension cost with contribution } C}_{APCost(C)} = & \\
 \underbrace{\text{Probability of bankruptcy}}_{(1-p)} \times \left(\underbrace{\text{Expected regulatory cost of pension}}_{\frac{\mu}{2}\mathbb{E}(S^2|C)} \right. & \quad (1.8) \\
 \left. - \underbrace{\text{Expected claimable pension surplus}}_{\mathbb{E}(S|C) - \mathbb{E}(\chi S|C)} \right) &
 \end{aligned}$$

A firm that goes bankrupt avoids any regulatory burden of maintaining the pension account when production fails, $\frac{\mu}{2}\mathbb{E}(S^2|C)$. It loses any pension surplus, when $\mathbb{E}(S|\bar{C}) - \mathbb{E}(\chi S|C) > 0$, and is not responsible for any deficit, when $\mathbb{E}(S|\bar{C}) < 0$. The “pension cost avoided in bankruptcy” when the firm contributes C , $APCost(C)$ in equation 1.8, is the cost of limiting moral hazard with the lender. Figure 1.6 sheds light on the potential magnitude of this cost for a sample of defined benefit firms.¹⁵ Throughout the 2000s, the median pension deficit is around 2 percent of non-pension assets; this number provides a lower bound on the pension cost avoided in bankruptcy.

A firm may choose to avoid this pension cost in bankruptcy by raising more debt relative to equity: position R1 or R2 in Figure 1.5. The firm that chooses position R1, $(I^*, C^*) = (I_R^*, \bar{C})$, borrows enough to contribute optimally, over-invests in risky production, and pays the associated efficiency cost of over-investment:

$$OICost(I_R^*) = \left(\mathbb{E}(z)f(I_S^*) - (1+r)I_S^* \right) - \left(\mathbb{E}(z)f(I_R^*) - (1+r)I_R^* \right)$$

The firm that chooses position R2 constrains the amount it borrows to force itself to invest closer to optimal in period 2. It raises enough debt to invest and contribute so that the marginal return to each is equal to the increase in the required bond repayment, $\frac{\partial b_R}{\partial B}$. The cost of committing to invest closer to optimal is a lower contribution to the pension account: $(I^*, C^*) = (I_R^* - \Delta I, \bar{C} - \Delta C)$. This firm avoids the full cost of over-investment,

¹⁵Section 5 describes the data and sample details.

but suffers the regulatory cost of under-contributing to the pension, facing efficiency cost:

$$\begin{aligned}
OICost(I_R^* - \Delta I) + UCCost(\bar{C} - \Delta C) &= OICost(I_R^* - \Delta I) \\
&+ p \underbrace{\{\mathbb{E}(S|\bar{C}) - \mathbb{E}(S|\bar{C} - \Delta C)\}}_{\text{Decrease in pension surplus}} \\
&- p \underbrace{\left\{\frac{\mu}{2}\mathbb{E}(S^2|\bar{C}) - \frac{\mu}{2}\mathbb{E}(S^2|\bar{C} - \Delta C)\right\}}_{\text{Change in implicit pension cost}} \\
&+ (1 - p) \underbrace{\{\mathbb{E}(\chi S|\bar{C}) - \mathbb{E}(\chi S|\bar{C} - \Delta C)\}}_{\text{Change in borrowing premium}} - (1 + r)\Delta C
\end{aligned} \tag{1.9}$$

The cost of under-contributing by ΔC , $UCCost(\bar{C} - \Delta C)$, has three components: a decrease in expected pension assets, a change in the implicit pension cost, and a change in the borrowing premium. This cost is increasing in the size of the optimal pension deficit, $\mathbb{E}(S|\bar{C}) < 0$, and the regulatory burden of under-contributing, μ . Quantitatively, the cost of under-contributing to a plan that is under-funded by 2% of firm assets, for example, includes the variable-rate PBGC premium – which increased from .9% to 2.9% of the pension shortfall since 2012 – and foregone investments due to future minimum required contributions. The cost of under-contributing to a surplus pension is lower claimable tax-free pension returns; as a result, the cost of under-contributing to a surplus pension decreased substantially after the 1990 imposition of the 50% excise tax. The cost of over-investment, $OICost(I)$, is a standard agency cost: firms are willing to accept risky projects that render a negative net present value because those projects increase the value to stockholders. Lenders charge the firms for this additional risk. Established estimates of this agency cost are modest; Leland (1998), for example bounds it between .3 and 1.4 percent of total assets. Its magnitude depends on firm- and project-specific factors – including the correlation between the firm and project cash-flow, the maturity structure of debt, and the marginal tax rate – and increases in the firm’s leverage ratio (Parrino and Weisbach, 1999).

A defined benefit firm increases debt issuance when the pension cost avoided in bankruptcy is high: $APCost(\bar{C}) > \min\{OICost(I_R^* - \Delta I) + UCCost(\bar{C} - \Delta C), OICost(I_R^*)\}$. Figure 1.6 suggests that this cost was higher for the median defined-benefit firm after 2000. A levered firm constrains its borrowing when the cost of doing so is lower than the full cost of over-investment: $OICost(I_R^* - \Delta I) + UCCost(\bar{C} - \Delta C) < OICost(I_R^*)$. The direct cost of under-contributing to a pension in deficit is between .9% and 2.9% of the shortfall; the direct cost of under-contributing to a pension in surplus is essentially zero following the imposition of the 50% excise tax. Accordingly, the conflict of interest among the stockholder, bondholder, and pension insurance agency encourages defined benefit firms to be

more likely to borrow on the extensive margin, but borrow less on the intensive margin. Pension regulation encourages defined benefit firms to borrow more on the intensive margin. This endogenous financing decision depends solely on the pension position and returns relative to investment risk and return.

1.4.2 Does the stockholder-bondholder conflict affect pension funding?

The conflict of interest between the stockholder and bondholder encourages defined benefit firms to contribute less to their pension accounts. The optimal contribution, \bar{C} , is a product of regulatory constraints and arbitrage incentives:¹⁶

$$\bar{C} = \max \left\{ \frac{\mathbb{E}\{1 + \rho\} - (1 + r)}{\mu \mathbb{E}\{(1 + \rho)^2\}} + D \left(\frac{\mathbb{E}\{1 + \rho\}}{\mathbb{E}\{(1 + \rho)^2\}} \right) - P, 0 \right\} \quad (1.10)$$

The firm has two incentives to contribute to the pension account. The first term in equation A.3 illustrates the arbitrage incentive. The sponsor will contribute more to the pension account when it expects a higher return on pension assets, $\mathbb{E}\{1 + \rho\}$, than it could receive on safe assets held in the firm, $1 + r$. Pension regulations are designed to encourage firms to maintain pension assets at a value close to the present discounted value of liabilities. The arbitrage incentive is therefore muted when the regulatory cost of deviating from exact funding, μ , or uncertainty on pension returns, $\mathbb{E}\{(1 + \rho)^2\}$ – and therefore the chance of a large surplus or deficit – is higher.¹⁷

A second incentive to contribute to the pension account arises from the magnitude of the current shortfall: $D - P$. The firm's optimal contribution is increasing in the size of pension liabilities, D , relative to current pension assets, P . While the magnitude of this contribution decreases one-for-one with current assets, it increases less than one-for-one with pension liabilities. This reflects the option value of pension liabilities. Defined benefit sponsors face an incentive to under-fund the pension to exploit the value of the put-option in bankruptcy.¹⁸ The zero-lower bound will constrain the contributions of firms that have a large amount of current pension assets or face a very low expected return on the pension account.

The firm's optimal contribution leads to an expected pension surplus that is decreasing in the magnitude of pension liabilities and increasing in the spread of the expected pension

¹⁶The firm cannot take money out of the pension account; the optimal contribution is bounded below by 0.

¹⁷This arbitrage incentive is discussed in length in Tepper (1980) and Black (1981).

¹⁸The option-value incentive to under-fund echoes the insight of Treynor (1976) and Sharpe (1977).

return over the safe return:¹⁹

$$\mathbb{E}(S|\bar{C}) = \frac{\mathbb{E}\{1 + \rho\}}{\mu\mathbb{E}\{(1 + \rho)^2\}} \left(\mathbb{E}\{1 + \rho\} - (1 + r) \right) - D \left(\frac{(\mathbb{E}\{1 + \rho\})^2 - \mathbb{E}\{(1 + \rho)^2\}}{\mathbb{E}\{(1 + \rho)^2\}} \right) \quad (1.11)$$

The optimal expected pension surplus or deficit, unsurprisingly, is determined by the same two incentives as the pension contribution: arbitrage and option value. The first incentive likely encourages a larger surplus: tax breaks on pension returns drive the expected return on pension investments above the after-tax safe rate. This incentive to hold a pension surplus is stronger when the regulatory cost, μ , of holding assets in the pension account is smaller; it dominates among firms that sponsor low pension obligations relative to their size. The option value associated with pension liabilities encourages firms with a larger magnitude of pension liabilities to maintain a lower funding ratio. This incentive dominates among small firms that sponsor large pension obligations relative to their size. In the 2000s, for example, untabulated results show that the funding ratio among firms in the lowest quartile of pension obligations to non-pension assets was 15% higher than the funding ratio among firms in the highest quartile.

The optimal contribution and expected pension surplus does not depend on the firm's productive investment prospects. However, this independence disappears when a firm facing complete financing markets chooses to contribute less than optimal to the pension account (financing position R2 in Figure 1.5). When the cost of contributing less is small relative to the cost of over-investment, the firm contributes less than optimal to the pension account by ΔC :

$$\Delta C = \frac{p(z^s f'(I_R^* - \Delta I) - (1 + r))}{\mu\mathbb{E}\{(1 + \rho)^2\}} = \frac{\frac{\partial b_R(B|E)}{\partial B^*}}{\mu\mathbb{E}\{(1 + \rho)^2\}} \quad (1.12)$$

Under these conditions, the productive investment prospects of the firm directly influence its pension contribution. A defined benefit sponsor facing a mean-preserving spread in the production return – ie., higher risk conditional on mean return: $\frac{z^S - z^F}{\mathbb{E}(z)}$ – makes a contribution that is further below optimal than a firm facing safer production. The deviation from optimal will be smaller when the expected regulatory cost of making it, $\mu\mathbb{E}\{(1 + \rho)^2\}$, is larger. As a result, small firms facing safe production processes will make smaller de-

¹⁹The expected pension surplus when the firm contributes C is $\mathbb{E}(S|C)$ below. Plugging in the optimal contribution \bar{C} gives for C gives the optimal surplus: $\mathbb{E}(S|\bar{C})$.

$$\mathbb{E}(S|C) = \ell \left((1 + \rho^S)(P + C) - D \right) + (1 - \ell) \left((1 + \rho^F)(P + C) - D \right) = \mathbb{E}\{(1 + \rho)\}(P + C) - D$$

viations from the optimal funding level. A contribution of $\bar{C} - \Delta C$ leads to a surplus of:

$$\mathbb{E}(S|\bar{C} - \Delta C) = \mathbb{E}(S|\bar{C}) - \mathbb{E}\{1 + \rho\}\Delta C \quad (1.13)$$

Conflicts of interest between stockholders and bondholders encourage the defined benefit sponsor hold a pension deficit that is larger than optimal by $\mathbb{E}\{1 + \rho\}\Delta C$: this impact of moral hazard between the stockholders and the bondholders on the amount of assets the PBGC can expect to claim in a termination depends on both the production process and the pension return. The cost this moral hazard imposes on the PBGC is higher when the production process is risky and expected productivity is low. The cost is lower when the pension process is risky and expected pension return is low.

1.4.3 The tax benefits of debt for firms with defined benefit pensions

The basic intuition that sponsoring a defined benefit pension encourages some firms to raise more debt and others to raise more equity is derived in a baseline model that abstracts from the corporate tax. Yet any analysis that discusses firms' trade-off between debt and equity finance would be remiss to ignore the tax benefits associated with debt. Under U.S. tax laws, interest payments to external bondholders are exempt from the corporate tax. Incorporating this tax benefit of debt into the model presented here confirms a classic theoretical result (Modigliani and Miller, 1963): while a non-pension firm is indifferent between debt and equity finance without taxes, the tax benefit of debt implies a non-pension firm strictly prefers debt finance.

Firms that sponsor defined benefit pensions in the baseline model without taxes are not indifferent between debt and equity: firms with high pension deficits relative to agency costs or regulatory pension costs prefer debt, while firms with lower pension deficits prefer equity. The tax exemption for interest payments will encourage some – but not all – of these firms to assume more debt. Like non-pension firms, pension firms face higher benefits of debt when interest payments are exempt from the corporate tax, but they also face higher agency costs to increasing leverage. The tax exemption encourages firms with high pension deficits and lower production risk to assume more debt, while firms with lower pension deficits and higher production risk will continue to prefer equity to debt finance.

Pension contributions and returns earned on assets held in the pension account are also exempt from the corporate tax. The previous analysis has assumed that this exemption is incorporated into the difference between the return on pension assets, ρ , and the return on safe investments, r . The model with taxes presented in Appendix B allows a more careful consideration of the role of the tax exemption for pension contributions in the firms fund-

ing, investment, and borrowing decisions. The tax exemption strengthens firms' arbitrage incentive to contribute to the pension account leading to a higher optimal contribution that increases with the tax rate: $\bar{C}^\tau = \bar{C} + \tau \left(\frac{1+r}{\mu \mathbb{E}\{1+\rho\}^2} \right)$. In this way, the exemption for pension contributions encourages firms to maintain better-funded pension accounts. Indeed, Thomas (1988) estimates that firms facing the corporate tax maintained a 13 percent higher funding status in their pensions than non-profit firms that did not face the corporate tax. The tax exemption for pensions also increases the after-tax benefit of contributing to the pension account relative to investing more in the firm. As a result, it encourages firms that face financial constraints and the stockholder-bondholder conflict to drain fewer funds from the pension to support investment. At the same time, many firms with large pension deficits – and, therefore, high benefits of debt relative to equity because of their pension – will increase borrowing to make higher optimal contributions. Contracting problems then imply that those firms make more risky investment and face higher agency costs.

The streamlined assumptions of this model abstract from two potentially important implications of the interaction between corporate taxes and defined benefit pensions. First, the static setting abstracts from some effects that would arise in a dynamic setting. For example, the tax exemption for pension contributions can decrease the firm's current and future taxable income. By functioning as a non-debt tax shield in this way, the pension exemption may lower the tax benefits of debt (DeAngelo and Marsulis, 1980; Shivdasani and Stefanescu, 2012). Second, the assumption that firms save pension assets in one investment with a safe return abstracts from asset allocation that could be motivated by differential tax treatment of assets inside and outside of the pension. Black (1980) and Tepper (1981) argue that firms should hold high-income investments, such as bonds, in their pension accounts and lower-income investments like equities in the general account of the firm.

1.4.4 Correlated pension and production returns

The baseline model abstracts from portfolio choice within the pension account. Yet a firm's optimal strategy may be to invest pension assets in a portfolio with returns that are correlated with the firm's production. As a result, the firm enjoys a higher pension payoff when it stays in business. A model extension in Appendix C allows the firm to choose between two portfolios in the pension account: one in which the returns are uncorrelated with investment returns on assets held in the firm, and another in which those returns are uncorrelated. In this extension, the benefits of debt are higher with correlated returns: the firm faces only upside risk in both production and the pension account. The cost of under-contributing to the pension is also higher, making it more likely that the firm will borrow enough to

contribute optimally and make riskier investment decisions. Yet the optimal contribution itself is lower when the firm faces moral hazard between stockholders and bondholders. As a result, pension accounts are better funded when the firm remains in business, but the income supporting pension benefits is less diversified. The model suggests that firms would prefer a pension allocation that is correlated with its own production return. Rauh (2009) shows that firms choose more conservative pension allocations when pension accounts are severely under-funded, but little other empirical work has been done to compare returns in pension accounts to returns on investments held in firms' general accounts.

1.4.5 Investment and Contributions Under Financial Constraints

The baseline model shows that sponsoring a defined benefit pension can introduce a wedge between the internal and external cost of funds. Contracting problems arising from pension regulation imply that pension debt magnifies existing agency costs of debt and encourages firms to make riskier investments. As a result, firms facing high non-contractible risk and small pension deficits prefer to finance with internal equity to avoid the agency costs associated with debt finance, while firms with large pension deficits and high costs to lowering their pension contributions prefer to finance with external debt so that equity holders pay lower pension costs in the bankruptcy state.

This finding speaks to a longstanding debate in corporate finance on whether an observed correlation between cash-flow and investment levels indicates the presence of financing constraints (Fazzari, et. Al, 1988; Kaplan and Zingales, 1997). Many theoretical models invoke a wedge between the internal and external cost of funds, like the one created by these pension incentives, to motivate cash-flow effects on investment in constrained firms: when firms face higher costs to external than internal financing, exogenous increases in cash will lead to higher investment. These direct cash-flow effects on investment are not the only possible explanation for empirical correlations between cash flow and investment levels. Unobserved investment opportunities are likely correlated with both cash flow and investment levels and can create the appearance of cash-flow effects on investment. A large empirical literature focuses on exogenous instruments for cash flow that identify the true effect of cash flow on investment levels.

One strategy in this literature, pioneered by Rauh (2006), has been to use legal differences in the minimum required pension contribution to instrument for cash-flow variation. Two approaches have been used to capture differences in minimum required contributions that are exogenous from unobserved investment opportunities. The first approach is to use policy changes that decrease the minimum required contribution for all firms (Dham-

bra, 2014; Kubick, et. Al, 2014). The policy change used in these papers – the Pension Funding Relief Act of 2012 – was the result of intensive lobbying efforts on the part of firms that struggled to make pension payments during the Great Recession. As such, it may not be strictly independent of the investment opportunities facing those firms. The second approach has been to use non-linearities in the formula used to calculate minimum required contributions as a function of the plan funding ratio. Rauh (2006) exploits these non-linearities with an instrumental variables specification that controls for the funding ratio, while Bakke and Whited (2012) use a regression discontinuity design that recognizes the funding ratio as the running variable. These non-linearities conditional on the funding ratio more plausibly identify differences in minimum required contributions that are exogenous from investment opportunities than policy changes that respond to business cycle dynamics. However, both approaches are vulnerable to a confounding factor identified by the model in this paper: even if changes in minimum required contributions are exogenous from unobserved investment opportunities, they directly affect firms’ regulatory cost of contributing less to the pension. Firms with higher regulatory costs to contributing less – higher minimum required pension contributions – will borrow more, maintain more cash-on-hand, contribute more to the pension, and make riskier investments. As a result, any empirical response to minimum required contributions captures not only be the direct cash-flow effect on investment, but also firms’ behavioral investment response to stronger borrowing incentives resulting from this dynamic.

1.5 Conclusion

This paper presents a new way of understanding the impact of defined benefit pensions on firms’ finance and investment decisions that takes into account the interplay between pension obligations and traditional agency problems arising from debt finance. It shows that well-understood concepts in finance may interact in unexpected ways when firms sponsor a defined benefit pension. Contracting inefficiencies associated with a defined benefit pension lead to a departure from the indifference result of Modigliani-Miller (1958); a defined benefit sponsor often prefers debt to equity finance, and contracting inefficiencies allow this preference to affect the value of the firm by changing its investment incentives. Further, an endogenous borrowing premium and decision, effective in reducing inefficiently risky investment decisions in many models,²⁰ may be unsuccessful in aligning the decisions of the

²⁰This model integrates risky investment in a way that is similar to Green (1983), but adds a step that allows the lender to pass on the agency costs of debt to the borrower: an endogenous borrowing premium and decision. As in Myers (1977), this borrowing premium encourages the firm to make socially optimal investments.

defined benefit sponsor with the incentives of its external lender. The common perception of the role of defined benefit pensions in corporate finance ignores the inefficiencies that arise from this important interaction between external and pension debt.

The interplay between contracting inefficiencies associated with defined-benefit pensions and conflicts of interest among stakeholders is unlikely to disappear, even as fewer new workers are offered a defined benefit pension. Volatility in asset prices and interest rates implies that the firm's optimal funding decision is a careful balance of macroeconomic expectations and regulatory incentives. Many firms that maintained well-funded pensions in the 1990s support under-funded pensions in today's macroeconomic environment. Other firms are terminating their defined benefit pension plans. A detailed literature describes several possible reasons for employer termination of pension plans;²¹ this paper suggests one more: contracting problems arising from the defined benefit pension magnify the agency costs of debt. Termination can be costly, and firms that terminate tend to be those with well-funded plans and substantial cash flow.²² This paper suggests that investment inefficiencies due to the defined benefit pension are more extreme among firms that sponsor under-funded plans and contribute only the minimum required to their pension account – a class of sponsors that is not terminating their pension plans.

The model presented in this paper suggests one mechanism to reduce inefficiencies associated with the defined-benefit pension: an actuarially-fair PBGC premium that includes not only a risk adjustment that incorporates risk due to the allocation of pension assets – a proposal that has been considered but set aside in recent policy discussions – but also a risk adjustment that internalizes the downside consequences of risky investment decisions the firm makes with general operating funds. Federal regulations that determine premiums, managed by Congress rather than the PBGC, are often set to maximize objective functions other than the optimal funding of the PBGC; a recent increase in premium rates, for example, was passed as a budget offset in the Bipartisan Budget Act of 2013. Without a change in this policy approach, employer-sponsored defined benefit pensions will remain a source of inefficiency that decreases the payoff to firms that sponsor those pensions, as well as generations of workers.

Millions of Americans continue to rely on employer-sponsored defined benefit pensions in their retirement, and will for decades to come. Employers themselves maintain these obligations, and fluctuations in the value of pension assets will influence firm decisions for just as long. The transition from defined-benefit to defined-contribution pensions represents

²¹ See, for example, Aaronson and Coronado, 2005; Rauh and Stefanescu, 2009; Kapinos, 2011.

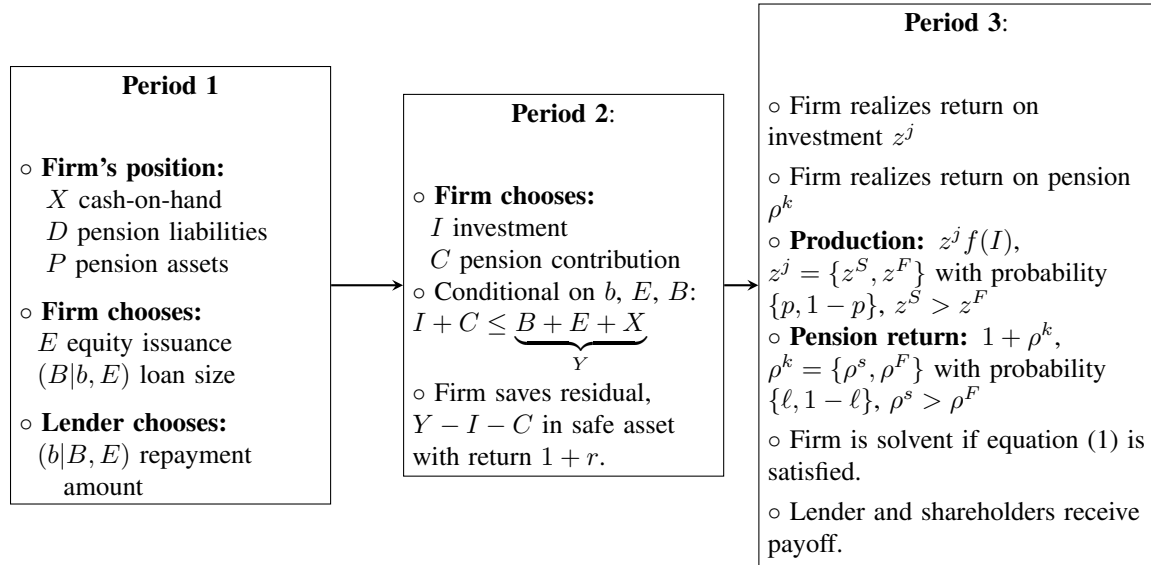
²² Terminating a pension plan required the firm to purchase annuities at market price for all accrued pension liabilities. Market price tends to be higher than the price firms assume when calculating plan funding ratios. Many firms are able to write down pension liabilities by offering lump-sum buyouts to their pensioners.

a sea change in the American economy. Literature on household savings has recognized that this transition has changed the way people manage and view their retirement security.²³ It will also change the way employers make financing and investment decisions and support their workers in retirement. While this dimension of the transition from defined-benefit to defined-contribution has been largely ignored, these employer decisions are integral both to the US economy and worker's retirement security: a firm that goes bankrupt because the structure of its pension encourages it to make risky investment decisions will exert a drag on the economy and be unable to support its workers in employment or retirement.

²³Poterba, Venti, and Wise, 2001; Love and Smith, 2008, Huggett, 1994; Poterba, Rauh, Venti, and Wise, 2007

Figures

Figure 1.1: Timing of events

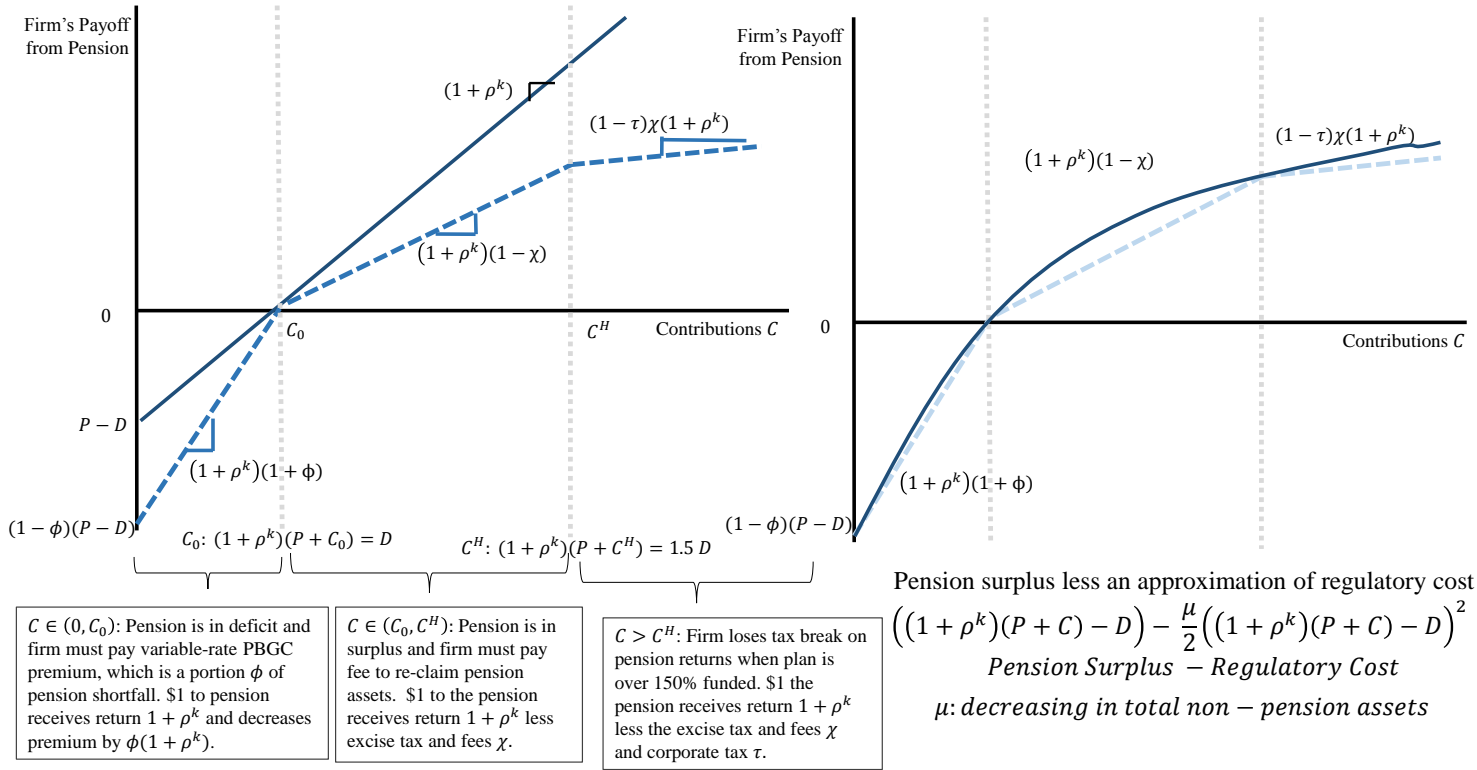


Notes. The model has three periods. The firm begins the first period with cash on hand X and an exogenous position in the pension account: pension assets P and liabilities D . With full information, the firm and lender know the expected realization of pension and production returns in period 3. These returns are independent in the baseline model. In the first period, the firm raises equity E , and the lender offers loans requiring repayment amount b conditional on the amount of equity the firm has raised and the loan size requested. The firm borrows an amount B at rate $\frac{b}{B}$, and cannot contract upon the distribution of funds in the second period. In the second period, the firm distributes its funds across pension contributions, productive investment, and a safe asset. In the third period, production and pension returns are realized. The firm goes bankrupt if it cannot repay its lender with assets held in the firm and the claimable portion of pension assets.

Figure 1.2: Approximation of the Firm's Payoff From Pension in Period 3

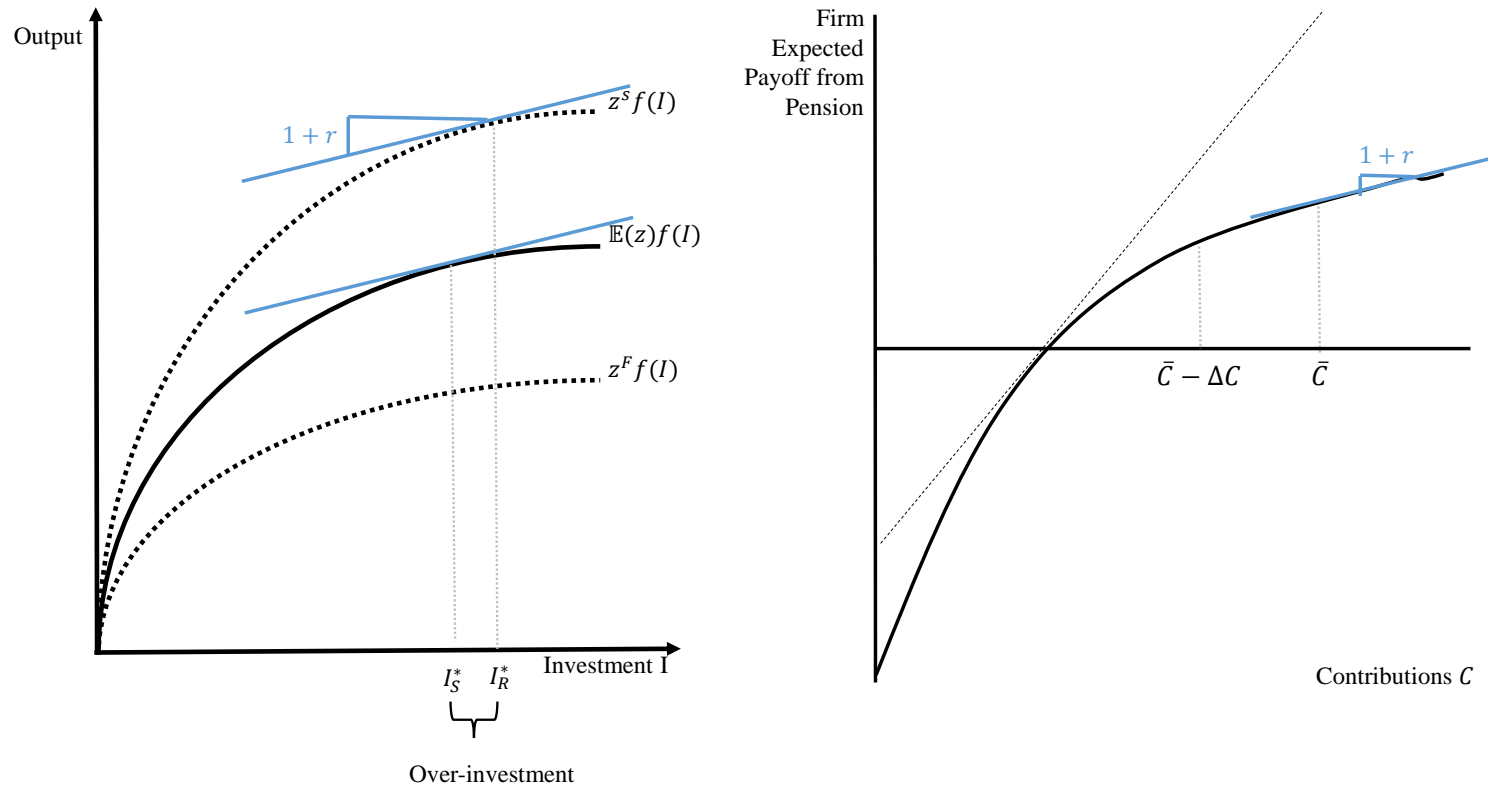
A. The impact of regulations on firm's payoff from pension

B. Functional approximation of firm's payoff from pension



Notes. Figure describes firm's payoff from its pension in period 3 when beginning period 1 with pension assets P and pension liabilities D , as a function of period-2 contributions C , if the firm avoids bankruptcy. Pension assets realize return ρ , but the firm also pays regulatory penalties that depend on the realized surplus or deficit. If C is low and the pension is in deficit in the period 3, the firm pays a portion of the pension shortfall $(D - P)$ as the variable rate premium. If firm realizes a pension surplus in the period 3, it pays an excise tax to re-claim pension assets. If the realized surplus is over 150% of liabilities, the firm loses its tax break on pension returns. Regulatory penalties are modeled as a quadratic approximation, which is assumed to take into account the expected future pension payoff.

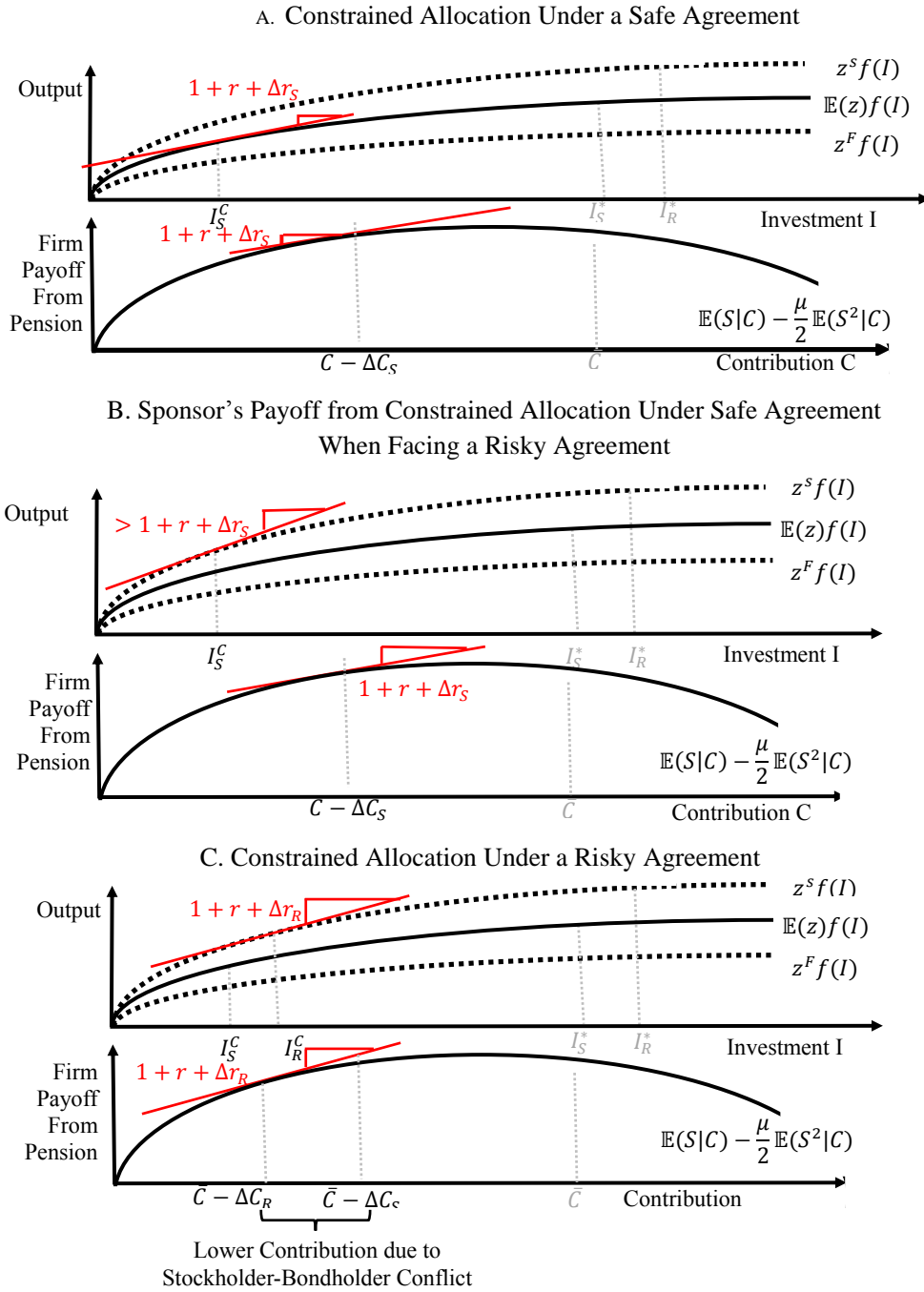
Figure 1.3: Optimal Allocations When Firm Faces Unconstrained Funds



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Notes. Optimal allocation to investment and pension contributions when firm saves in safe asset with return $1 + r$; To do so, firm raised sufficient funds in 1st period to invest and contribute to point where marginal return to pension contributions and investment is equal to return on safe assets, $1 + r$. I_S^* is socially optimal level of investment when a firm signs a safe agreement and does not face moral hazard, while I_R^* is the optimal investment for a firm that signs a risky agreement and faces moral hazard. Firm signing risky agreement pays cost of over-investment through a higher borrowing rate. Because the pension and production returns are independent, firms signing safe agreement (do not face moral hazard) and risky agreement (face moral hazard) both experience the upside and downside risk to pension contributions. Both types of firms optimally contribute \bar{C} to pension. \bar{C} is contribution firms choose given exogenous regulatory constraints.

Figure 1.4: Optimal Allocations When Firm Faces Constrained Funds

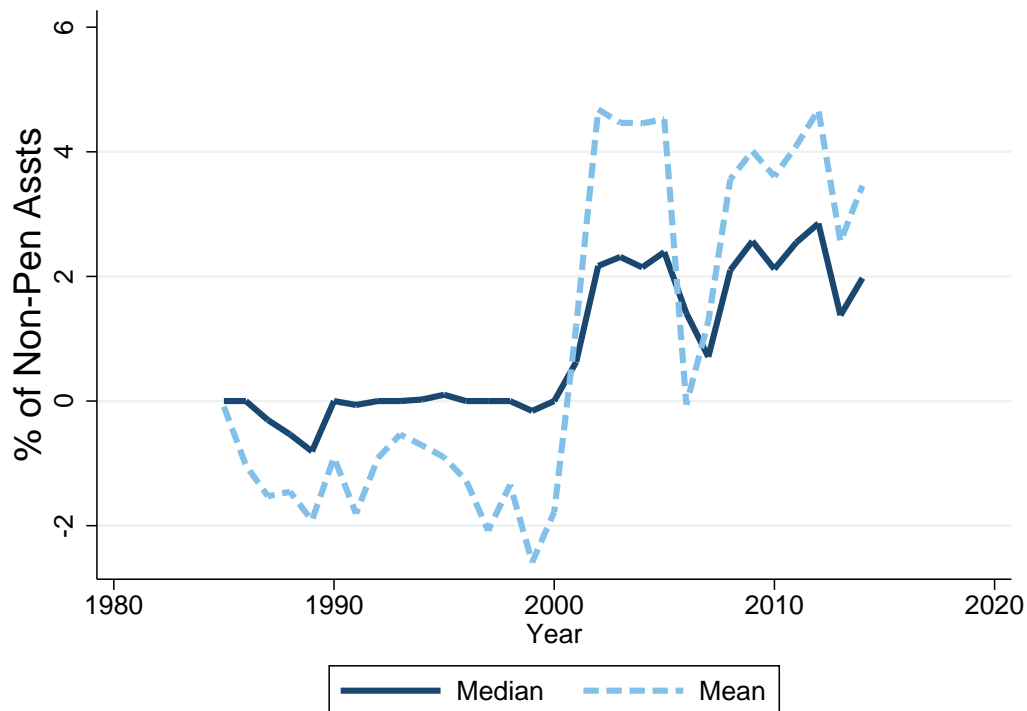


Notes. Firm's allocation under safe and risky agreements when the amount of funds raised in first period cannot cover the interior solutions: $Y^* < I_S^* + \bar{C}$. A plots the constrained allocation for a firm facing a safe agreement ($I_S^C, \bar{C} - \Delta C_S$). In B, a firm facing a risky agreement would receive a higher marginal return to investment than contributions at that allocation. Therefore, in C, firm invests a higher amount in production and contributes less to the pension, ($I_R^C, \bar{C} - \Delta C_R$). When firm faces exogenous financing constraints, moral hazard encourages it to invest closer to the social optimum, but does so at the expense of pensioners.

Figure 1.5: Three Endogenous Financing and Allocation Decisions

- S1.** A firm that raises primarily equity will invest at the social optimum and contribute at the firm's optimum: (I_S^*, \bar{C}) . The firm receives a marginal return of $1 + r$ on investments, contributions, and the safe asset.
- R1.** A sponsor that raises primarily debt and faces a low cost to over-investment relative to the cost from under-contributing will over-invest and contribute optimally to its pension: (I_R^*, \bar{C}) . The firm receives a marginal return of $1 + r$ on investments, contributions, and the safe asset.
- R2.** A sponsor that raises primarily debt and faces a high cost to over-investment will endogenously constrain its period-2 operating funds to invest closer to the social optimum and under-contribute to its pension plan: $(I_R^* - \Delta I, \bar{C} - \Delta C)$, where $I_S^* < I_R^* - \Delta I < I_R^*$. The firm does not save in the safe asset, and receives a marginal return on investments and contributions equal to the increase in the borrowing rate resulting from borrowing an additional dollar: $\frac{\partial b_R}{\partial B}$.

Figure 1.6: Independent Pension Debt As Percent of Non-Pension Assets



Notes. Data drawn from Compustat. Sample includes all firms in Compustat for at least 10 years between 1976 and 2012, and either reported a pension in each year or never reported a pension. Independent pension debt is all pension debt reported on the firm's balance sheet. Non-Pension assets are all assets, cleansed of pension assets according to the method in appendix D.

CHAPTER 2

Pension Obligations and the Cost of Corporate Debt

How does sponsoring defined benefit pensions influence firms' cost of borrowing? Like traditional corporate bonds, pension debt is a long-term liability that influences default risk and firm value – two important determinants of bond spreads. Yet this paper suggests that tax, regulatory, and agency incentives associated with pension obligations imply a substantially different impact of pension leverage on bond spreads than more standard forms of leverage. In fact, a ten percentage point increase in unfunded pension liabilities raises defined benefit firms' bond spreads by 23 basis points, while an equivalent increase in standard external leverage increases bond spreads by only 2.6 basis points.

2.1 Introduction

Defined benefit pension obligations sponsored by private employers amount to over three trillion dollars in the U.S. economy. These pension obligations offer firms a unique type of borrowing: by under-funding their pension accounts, firms can borrow from their own workers and pensioners. In the presence of frictions such as bankruptcy costs, taxes, and agency problems, the financing structure of firms can influence the spreads they face on corporate bonds. While existing literature has explored the impact of a wide range of financing arrangements – including traditional debt, equity, and lines of credit – on firms’ bond spreads, it has largely ignored the role of unfunded pension obligations. This paper fills that gap by asking how unfunded pension liabilities influence the spreads firms face on corporate bonds.

In the standard trade-off theory of capital structure, bond spreads depend on firms’ capital structure. Firms choose their optimal leverage ratio by trading off the benefits of external debt with its costs. Benefits of external debt include tax benefits (Kraus and Litzenberger, 1973; Miller, 1977; Graham, 2000, 2006) and agency benefits from controlling self-interested managers (Jensen, 1986), while its costs include direct bankruptcy costs, debt overhang (Myers, 1977), and asset substitution (Jensen and Meckling, 1976). Higher benefits of external debt lead to higher leverage ratios and bond spreads; higher costs of external debt lead to lower leverage ratios and bond spreads.

Defined benefit pensions can affect both the costs and benefits of debt, in turn influencing the bond spreads pension firms face on corporate debt. Understanding the intricacies of this relationship requires focusing not only on how pension debt is integrated into firms’ capital structure, but also how it influences their investment decisions. If pension leverage and external leverage are perfect substitutes, a firm that maintains pension debt equal to 20 percent of its assets will face the same borrowing rate as a firm that maintains external debt equal to 20 percent of its assets. Yet if market frictions associated with that pension debt encourage the firm’s managers to make different investment decisions than they would with only external debt, an increase in pension debt could have a different impact on corporate bond spreads than an equivalent increase in external debt.

While sponsoring a defined benefit pension can allow firms to borrow from their pensioners, pension funding regulations imply that pension debt is not, in fact, as flexible as external debt. Pension assets are earmarked to pay future pension obligations and held in a legally separate account. A combination of regulations on plan terminations and excise taxes essentially prohibit firms from using assets held in the pension account for general firm expenses. Firms can “borrow” from their pensioners by constraining the amount of

money they contribute to their pension account. Just as firms are required to make interest payments on external loans, firms are also required to make contributions to underfunded pension accounts. Unlike interest payments, however, these contributions do not reflect the investment risk of a firm; rather, they depend on the amount of pension liabilities that are under-funded and the number of pensioners the plan covers. In this way, firms with underfunded pension liabilities are borrowing from a lender (pensioners) that does not charge a risk premium to internalize the consequences of risky investments.

How does this unique type of debt influence the borrowing rates that firms face from traditional bondholders? Existing literature provides some theoretical insights to this question. First, Treynor (1976) and Sharpe (1977) envision pension obligations to be analogous to external debt: put options with longer maturities. Echoing Black and Scholes (1973) and Merton (1974), this theory suggests that pension obligations will be valued like traditional external debt and, by extension, have a similar impact on firms' borrowing rates. Empirical evidence on whether pension debt is empirically priced like external debt is mixed. Black (1980) and Feldstein and Seligman (1981) find that pension debt is priced analogously to traditional debt. These papers, however, used data from an earlier regulatory regime that did, in fact, treat pension and external debt more alike. More recent papers (Coronado, et al, 2007; Gold, 2005) find that pension obligations tend to be mis-priced, suggesting that investors have different perceptions of pension debt and external debt.

More recent theoretical considerations highlight the impact of pension debt on the costs and benefits of traditional external debt. Pension debt can be a tax shield: pension contributions, exempt from the corporate tax, function as non-debt tax shield that decreases the tax benefits associated with debt (D'Angelo and Masulis, 1980; Graham, 2006; Shivdasani and Stefanescu, 2012). Shivdasani and Stefanescu (2012) estimate the tax savings associated with pension debt to be 2.1 percent of book assets; these savings translate to lower tax benefits of debt, and could encourage firms to take on less debt at lower rates. Firms' managers may also have a different agency relationship with their pensioners than with their bondholders. When managers internalize pensioners' payoffs in bankruptcy – either due to an innate sense of responsibility to their workers or because they are compensated with defined benefit pensions (Sundaram and Yermack, 2007) – pension debt functions as inside debt: higher levels of pension debt align managers' interests with those of bondholders, encouraging them to make investments consistent with bondholders' interests, decreasing agency costs of debt, and lowering the spread bondholders require. Choy et al. (2014) explore this hypothesis and suggest that managers do, indeed, increase risk following a decrease in pension debt associated with a freeze.

Alternatively, the agency relationship between managers and pensioners may mirror

that between managers and bondholders. Yet regulatory structures preclude pensioners from using the same tools – such as bond covenants and risk premia – that bondholders use to manage agency costs. As a result, firms with pension debt equal to 20 percent of its assets will make riskier investment decisions than firms with external debt equal to 20 percent of its assets. Traditional bondholders may recognize this incentive and raise spreads accordingly (Lay, 2016).

This paper conducts a systematic analysis of four theories of the relationship between pension debt and spreads on new bond issuances identified in existing literature. These theories suggest viewing pension debt as (1) a substitute for external debt, (2) a non-debt tax shield that lowers the tax benefits of debt, (3) inside debt that aligns managers' interests with those of bondholders, or (4) external debt with imperfect agency control mechanisms. Section 2 uses a simple graphical exposition of the supply and demand of a firm's debt to describe each theory and translate these theories into testable empirical predictions. A strict interpretation of the first theory suggests that a change in pension leverage will have the same impact on firms' bond spreads as an equivalent change in external leverage. The second theory suggests that unfunded pension obligations decrease the tax benefits of debt because pension contributions replace interest payments as corporate tax shields. The third theory suggests that when pension debt functions as inside debt, higher pension debt will encourage managers to make fewer inefficient private investments and, in turn, lower borrowing rates. The fourth theory, viewing pension debt functions as outside debt without internalized investment risk, suggests that firms with higher pension debt will take on more external debt, make riskier investments, and face higher bond spreads on new issuances.

This paper uses two sources of data to explore the relationship between pension debt and bond spreads for publicly-listed firms. Compustat, compiled from annual financial statements of publicly-listed firms, describes the general financial status of a firm and reports limited information on pension assets and liabilities. Deal Scan, a database of loans constructed by the Loan Pricing Corporation (LPC), describes characteristics of loans to large firms. These datasets are linked using the publicly-available Dealscan-Compustat Link Data created by Michael Roberts and provide detailed information on a broad array of potential determinants of bond spreads.

This paper examines the relationship between defined benefit pension obligations and bond spreads in six steps. Section 2.2 discusses related literature. Section 2.3 describes four theories of the interaction between defined benefit pension obligations and the cost of corporate debt, and translates these theories into empirical predictions. Section 2.4 describes relevant data from publicly-listed firms. Section 2.5 uses cross-sectional regressions to find that an increase in pension leverage raises firms' bond spreads almost 9 times more than

an equivalent increase in external leverage. These findings support the view that pension debt functions as external debt with imperfect agency control mechanisms. Section 2.6, therefore, investigates a further prediction of the fourth model: increases in bond spreads associated with pension debt are higher when firms face higher initial agency costs of external debt. Section 2.7 concludes.

2.2 Related Literature

This work is related to three strands of literature. First, the theory of capital structure informs the understanding of how pension obligations influence bond spreads. Starting with the seminal work by Merton (1974), a contingent-claims framework suggests that the borrowing rate a firm faces is a function of the firm's default risk and amount of funds available to repay lenders in the event of default. Subsequent work has expanded this framework to address the impact of frictions such as the tax benefits of debt (Graham, 2000), moral hazard between manager and bondholders (DeMarzo and Fishman, 2007a), and agency costs associated with asset substitution (Mello and Parsons, 1992; Leland, 1994). Each of these expansions are critical in understanding how pension debt influences corporate bond spreads.

A second strand of related literature investigates optimal contracting associated with capital structure. Asvanunt, et al. (2011) suggest that credit lines may be a better mechanism than cash to manage liquidity because those credit lines are able to reduce agency costs associated with principle-agent problems between the bondholder and manager. DeMarzo and Sannikov (2006) similarly show that traditional loan commitments are an important component of a firm's capital structure because they manage moral hazard problems between managers and bondholders. These papers are related to the current one in that they emphasize that different capital structures will manage agency relationships, and thus firms' borrowing rates, in different ways. An important implication of the present paper is that pension debt, an often overlooked component of firms' financial structure, can exacerbate some agency costs but minimize others. These behavioral effects associated with sponsoring defined benefit pensions can have important impacts on firms' borrowing rates. Perhaps they, too, could be taken into account when considering the optimal capital structure of a firm that sponsors defined benefit pensions.

The final strand of literature related to the present paper investigates the determinants of bond spreads. Collin-Dufrense et al. (2001) and Huang and Huang (2012) show that variation in credit spreads cannot be fully explained by firm-level characteristics that are traditionally used to proxy for default risk and firm solvency – the two factors that the

contingent-claims framework predicts determine capital structure and borrowing rates. Several papers work to explain this unexplained variation by considering factors that later models predict to explain variation in bond spreads. By constraining managers' behavior, bond covenants have the potential to decrease agency costs associated with external borrowing. Chava and Roberts (2008) and Bradley and Roberts (2015) find that, empirically, certain bond covenants are associated with lower credit spreads. Information asymmetry between lender and manager may also lead to higher borrowing rates; accordingly, Bharath et al, (2009) find that firms with closer relationships to their lenders pay lower rates. Other works have cited a variety of factors leading to lower bond spreads, including securitization (Nedauld and Weisbach, 2012), operating in more competitive product markets (Valta, 2012), and lackluster corporate responsibility (Oikonomou et al., 2014). This paper explores one more factor – pension obligations – that may explain the difference in borrowing spreads across firms.

2.3 Pension Leverage, External Leverage, and Bond Spreads

This section explores four theories of the relationship between pension debt and borrowing rates: (1) pension debt as a put option that substitutes for external debt (Treynor, 1977; Sharpe, 1976), (2) pension debt as a non-debt tax shield that lowers the tax benefits of debt (D'Angelo and Masulis, 1980; Shivdasani and Stefanescu, 2012), (3) pension debt as inside debt that aligns managers interests with that of bondholders (Choy, 2015), and (4) pension debt as outside debt that magnifies existing agency costs of debt (Lay, 2016).

Each theory is described using a simple graphical exposition of the supply of and demand for one firm's new debt issuances. This graphical exposition distinguishes three types of leverage. *Pension leverage* is the ratio of total unfunded pension liabilities to non-pension assets, where unfunded pension liabilities are the present discounted value of projected benefit promises less the market value of assets held in the firm's pension account. *External leverage* is the ratio of traditional long-term debt held on the balance sheet to non-pension assets. Finally, the legal separation between pension assets and general firm assets motivates a non-traditional definition of total leverage: *total leverage* is the sum of pension leverage and external leverage.¹

¹Pension obligations and assets are reported in firms' financial statements in the footnotes. Total firm assets and liabilities are adjusted through the cash flow statement to reflect year-to-year changes in the pension account. Shivdasani and Stefanescu (2012) propose integrating pension liabilities through a consolidated balance sheet approach. In contrast, the method in this paper considers unfunded pension liabilities to directly add to total debt. Regressions control for the level of total pension obligations, discussed further in following sections.

To introduce this graphical framework, consider the demand for and supply of corporate debt when a firm does not sponsor a pension in Figure 2.1a. S^* represents the firm's supply of corporate debt, while D^* represents investors' demand for corporate debt issued by the firm. The total amount of funds a firm raises through external debt and equity is fixed. The horizontal axis represents the firm's external leverage ratio: as a firm moves rightward, debt finance increases relative to equity finance. The vertical axis represents returns to the risk-neutral firm and investors. The convention in the corporate finance literature of placing returns, rather than price, on the vertical axis implies that – unconventionally – supply slopes down and demand slopes up. In a slight departure from this convention, the vertical axis in this paper represents gross returns rather than risk-adjusted returns. In this figure, the firm without a pension will select a leverage ratio L^* and borrow at rate r^* . This firm faces a spread over the risk-free rate of $r^* - r_{safe}$.

The benchmark model in Figure 2.1a is built on several classic models of finance. Under the assumptions of Modigliani and Miller (1958), the firm's supply of and investors' demand for corporate debt would be represented by overlapping horizontal lines at the safe rate: with perfect markets, no taxes, no bankruptcy risk and no agency conflicts, the firm is indifferent between debt and equity finance. Taking into account the tax exemption for interest payments, the firm's supply of corporate debt shifts up to a horizontal line at $\frac{r_{safe}}{1-\tau}$, where τ is the corporate income tax: when interest payments are exempt from the corporate tax, the firm strictly prefers debt finance (Modigliani and Miller, 1963). However, as corporate income is finite, this tax benefit of debt will decrease as leverage – and, therefore, interest payments – increase. Taking into account tax carry-forwards and carry-backs, Graham (2000) suggests that the firm's supply curve has a “kink” after which it slopes down: the tax benefit of debt encourages debt finance to the extent that the firm has taxable income to shield with interest payments. Further, when there is a conflict of interest between managers and shareholders, the firm also faces an agency benefit of debt that shifts the supply curve up and amplifies its downward curvature (Jensen, 1986): recurring interest payments associated with debt prevent managers from using cash flow to fund projects with private benefits. This agency benefit decreases marginally as the amount of debt, and therefore level of recurring interest payments, increases. Finally, bankruptcy risk and conflicts of interest between stockholders and bondholders lead to an upward curvature in investors' demand for the firm's debt (Greene, 1985; Myers, 1977). With low levels of leverage, the firm faces little risk of bankruptcy and lenders lend to the firm at the risk-free rate, r_{safe} . As leverage increases, the firm faces possible bankruptcy and the incentive to make investments that are riskier than those in the lender's interest. The lender, setting the return so that it receives the safe rate in expectation, raises the required borrowing rate and thus inter-

nalizes this agency cost of debt to the firm (Greene, 1985; Myers, 1977). The combination of these incentives motivate the shape of the benchmark demand and supply curves, D^* and S^* , in Figure 2.1(a).

The following subsections use similar graphical analysis to describe each of the four theories of pension debt and bond spreads listed above. The assumptions underlying each theory differ in three important ways: how they capture current regulations facing firms that sponsor defined benefit pensions, how pension debt influences firms' default risk, and whether managers interests align more closely with the pensioners or the stockholders. Each subsection lays out these assumptions in describing the role of pension debt in determining bond spreads. Throughout this analysis, consider the model presented in Figure 2.1(a) as the benchmark without pensions, and assume that the firm can finance with equity, external debt, and pension debt. Three leverage ratios are of interest: external leverage is the ratio of external debt (long-term bonds) to total assets, pension leverage is the ratio of pension debt (unfunded pension liabilities) to total assets, and total leverage is the ratio of the sum of pension and external debt to total assets.

2.3.1 Pension debt as a put option

Figure 2.1(b) describes the direct effect of pension debt on bond spreads when it is envisioned as a simple put option that does not affect tax benefits or agency relationships (Sharpe, 1976). In this figure, total funds – equity, external debt, and pension debt – remain fixed, but an increase in pension leverage increases total leverage and, in turn, increases bond spreads. The red lines represent the supply and demand for the firm's external debt at different levels of pension leverage. The dashed line represents the firm with a pension deficit, while the dotted line represents the firm with a pension surplus. External leverage is fixed at each point on the horizontal axis, but pension leverage increases as the demand curve shifts from D^* to D_D^{put} and decreases as the demand curve shifts from D^* to D_S^{put} . As a result, total leverage increases from D^* to D_D^{put} and decreases from D^* to D_S^{put} .

Suppose the firm holds external debt equal to 20 percent of its assets and a pension surplus equal to 5 percent of non-pension assets. This firm's external leverage ratio is .2 and pension leverage ratio is -.05. Without further frictions, this pension surplus decreases the total leverage ratio to .15. Relative to the firm without a pension in Figure 1(a), this corresponds to a shift of the demand curve for *external* debt to the right by .05. The firm with a pension surplus will borrow more externally at a lower interest rate. Now, suppose the firm has a pension deficit equal to .05 percent of firm assets. This firm faces a total leverage ratio of .25, and the demand curve for its external debt shifts to the left by .05:

it will borrow less externally and face higher bond spreads in equilibrium. Assuming that changes in pension debt do no influence the agency or tax benefits of external debt, the supply of external debt does not shift with pension debt. As a result, this model suggests that the firm's borrowing rate increases with pension debt.

Figure 2.2(a) describes the indirect effect of pension debt on bond spreads when it is envisioned as a simple put option. As in Figure 2.1, total funds in Figure 2.2 remain fixed and the red lines represent the supply and demand for the firm's external debt at different levels of pension leverage.² Unlike Figure 2.1, the horizontal axis represents total leverage instead of external leverage. Since total leverage is fixed at each point on the horizontal axis, the increase in pension leverage as the demand curve shifts from D^* to D_D^{put} coincides with an equivalent decrease in external leverage. Analogously, the decrease in pension leverage as the demand curve shifts from D^* to D_D^{put} coincides with an equivalent increase in external leverage. In Figure 2.2, therefore, movements from the non-pension supply and demand curves, S^* and D^* , to the pension supply and demand curves, $S_{D \text{ or } S}^{put}$ and $D_{D \text{ or } S}^{put}$, represent changes in the composition of total leverage rather than changes in the level of total leverage.

In the put option model, the firm makes the same investment choices when its total leverage is fully comprised of pension leverage as it does when its total leverage is fully comprised of external leverage: there is no behavioral response or indirect effect of pension liabilities. Therefore, the firm faces the same bond spread and total leverage ratio with a pension as it does without: $D^* = D_D^{put} = D_S^{put}$ and $S^* = S_D^{put} = S_S^{put}$. This interpretation of the put option model of pension liabilities relies on several important assumptions that imply pension debt and external debt are perfect substitutes. First, it abstracts from any effect that the maturity of debt may have on the costs or benefits of debt to the firm. Second, it assumes that the impact of pension debt on default risk is the same as the impact of external debt on default risk. Third, it assumes that agency relationships between the manager and pensioner are the same as those between the manager and the bondholder. These assumptions imply that substituting pension debt for external debt does not influence the *slope*(b) of the supply or demand curve in Figure 2.1(a) and, as a result, there are no indirect effects of pension leverage on the bond spread in Figure 2.2.

Regulations facing firms that sponsor defined benefit pensions likely undermine the validity of these assumptions. Pension assets are held in legally separate accounts that imply that firms cannot borrow from their pensioners at will. Further regulations allow firms to

²In each subfigure of Figure 2.2, the dotted lines represent a pension surplus and the dashed lines represent a pension deficit. Where the supply or demand curves for a firm with a pension surplus or pension deficit overlap, they are dash-dotted.

default on pension debt when the firm is in trouble without entering bankruptcy proceedings. Finally, pensioners and bondholders are significantly different types of lenders that have different mechanisms available to them to manage the firms' investment decisions and may have different agency relationships with the borrower.

2.3.2 Pension debt as a non-debt tax shield

The regulatory exemption of interest payments from the corporate income tax creates tax benefits of external debt relative to equity financing (Modigliani and Miller, 1963). Pension contributions are similarly tax exempt and may function as non-debt tax shields that lower these tax benefits of debt (D'Angelo and Masulis, 1980; Shivdasani and Stefanescu, 2012). Firms with higher pension debt make more tax-exempt contributions. By decreasing the tax benefits of debt, pension debt could lead to lower equilibrium levels of external leverage and lower bond spreads.

Figure 2.1(c) describes the direct effect of pension debt on the firm's bond spread when the firm enjoys a tax exemption on pension contributions. As in Figure 2.1(b), a pension surplus will shift investors' demand for external debt to the right, and a pension deficit will shift the investors' demand for external debt to the left. The tax benefits of debt accrue strictly to the firm and, therefore, only affect the supply of debt. The reductions in the tax benefits of debt are realized through tax exempt pension contributions; as a result, the demand curve shifts to the left as expected pension contributions decrease the firm's taxable income. If the firm with a pension surplus does not plan to make pension contributions, then the firm's supply curve remains unchanged ($S_s^{tax} = S^*$). A firm with a pension deficit, on the other hand, likely plans to make contributions. The resulting tax shield lowers the firm's tax benefit of debt, shifting the supply curve from S^* to S_d^{tax} . Positive pension contributions associated with pension debt lead lower tax benefits of external debt and lower spreads on external debt.

Figure 2.2(b) describes the indirect effect of pension debt on bond spreads, taking into account the tax shield provided by pension contributions. Since this tax shield does not influence investors' demand for the firm's external debt, the demand curve does not change as a function of total leverage: $D^* = D^{put}$. Similarly, when the firm has a pension surplus and does not plan to contribute, there is no change in the supply curve as a function of total leverage: $S^* = S^{put} = S_S^{tax}$. However, when the firm plans to contribute to a plan in deficit, the supply of external debt as a function of total leverage may differ from the supply as a function of external leverage. If one dollar of pension debt implies more tax-exempt lifetime payments than one dollar of external debt, pension debt decreases the tax benefits

of external debt less than an equivalent increase in external debt. In this case, the firm with a pension deficit faces supply S' in Figure 2.2. If one dollar of pension debt implies fewer tax-exempt lifetime payments than one dollar of external debt, pension debt decreases the tax benefits of external debt less than an equivalent increase in external debt. In this case, the firm with a pension deficit faces supply S'_D in Figure 2.2. If one dollar of pension debt implies more tax-exempt lifetime payments than one dollar of external debt, pension debt decreases the tax benefits of external debt more than an equivalent increase in external debt. In this case, the firm with a pension deficit faces supply S''_D in Figure 2.2. If one dollar of pension debt implies the same amount of tax-exempt lifetime payments as one dollar of external debt, pension debt does not have an indirect effect on external debt and the firm with a pension deficit faces supply S^{put} in Figure 2.2.

This interpretation relaxes one assumption made in the previous subsection to incorporate the tax exemption of pension contributions. In figures 2.1(c) and 2.2(b), pension debt influences the tax benefits of debt. The preceding discussion remains agnostic on how pension regulations may influence the level of lifetime pension payments incurred by one dollar of pension debt relative to lifetime interest payments incurred by one dollar of external debt. The following analysis, however, assumes that lifetime payments incurred by the two types of debt are the same. This assumption reflects the fact that one dollar of pension debt incurs the same present discounted value of obligations as one dollar of external debt at the same maturity. It also eases exposition of the next theories of pension debt.

2.3.3 Pension debt as inside debt

In the theories discussed to this point, agency relationships between managers and pensioners mirror those relationships between managers and bondholders. This assumption implies that firms with pension leverage make the same investment decisions as firms with an equivalent level of external leverage. The third theory relaxes this assumption. It posits that pension debt is an important source of inside debt that aligns managers interests with that of bondholders (Sundaram and Yermack, 2007; Choy et al., 2014). When firms finance with such inside debt, lenders are willing to accept lower spreads on their corporate bonds (Anantharaman et al., 2011).³ Unfunded pension liabilities function as inside debt when managers internalize realized payoffs to pensioners in bankruptcy. As these realized payoffs are unsecured and similar to the payoffs debtholders realize in bankruptcy, pension debt aligns managers' interest with that of other debtholders. Managers may internalize

³This article shows that private lenders do in fact offer lower spreads when they see inside debt – they recognize these incentive alignment effects.

payoffs to pensioners in bankruptcy if they themselves are compensated with pensions, or intrinsically care that pensioners receive their full promised pension payment.

The impact of this agency relationship on bond spreads functions through an indirect effect: when the composition of leverage shifts toward pension debt, the agency benefits and costs associated with external debt change in a way that encourages managers to make different investment decisions. These different investment decisions, in turn, influence the supply and demand for the firm's debt. When pension debt functions as inside debt, increases in pension leverage increase the manager's incentive to maximize the value of the firm in bankruptcy. This has two effects on the agency benefits and costs of external debt. First, the agency benefits of debt payments in managing spendthrift managers will decrease. Second, asset substitution arising from agency problems between stockholders and debtholders also decreases: managers, maximizing the value to stockholders, make less risky investments with more inside debt and debtholders accept lower bond spreads as a result.

Figure 2.2(c) describes the impact of these effects on the supply of and demand for the firm's debt. Consider first the firm with a pension surplus. In bankruptcy, it can terminate its pension and use surplus funds to repay debtholders. Its debtholders, in turn, expect higher payouts in bankruptcy and will accept lower bond spreads. The demand for the firm's debt, relative to when it does not have a pension, shifts from D^* to D^1 . At the same time, the pension surplus ensures that pensioners will be fully repaid in bankruptcy and, because the surplus pension is not inside debt, the agency benefits of external debt remain unabated. The supply curve remains the same: $S_S^{ID} = S^*$.

Suppose, instead, the firm faces a pension deficit. With a pension deficit, the payoff to pensioners (and managers) depends on the value of the firm in bankruptcy. This deficit functions as inside debt: managers are less likely to divert firm resources to self-interested projects and make less risky investments to maximize the value of the firm in bankruptcy. The agency benefits of external debt decrease (supply shifts down to S_D^{ID}) and bondholders are willing to accept lower rates (demand shifts right to D_D^{ID}). This theory implies that as leverage shifts toward pension debt and away from external debt, borrowing rates fall.

This interpretation of pension debt as inside debt makes two assumptions. First, it assumes that one dollar of pension debt leads to the same tax exempt payments as one dollar of external debt. Second, it assumes one particular form of the agency relationship among managers, bondholders, and pensioners. The next section explores a situation in which managers do not internalize pensioners' losses in bankruptcy.

2.3.4 Pension debt as external debt with imperfect agency control

Now suppose that managers view pension debt as traditional outside debt. Three regulations associated with the pension account constrain these managers from using traditional mechanisms to control agency costs when borrowing from pensioners. First, pension assets are held in a legally separate account and cannot be claimed by other lenders in bankruptcy. Second, required pension payments do not reflect the full downside risk associated with the firms' investment. And third, firms cannot make covenants with pensioners. These contracting problems cause pension debt to magnify existing agency costs between stockholders and bondholders. As a result, firms with high pension debt pay higher bond premiums to external lenders (Lay, 2016).

Figure 2.2(d) describes the impact of these regulations on the supply and demand for a firm's bonds. Suppose the firm sponsors a defined benefit pension that is in surplus. The dotted line in Figure 2.2(d) represents this situation. A pension surplus decreases the firm's overall leverage ratio since those assets can be liquidated to repay external claimants, increasing the expected return to lenders at any given level of leverage. These lenders, operating in a competitive market, lower their demand for the firm's debt from S^* to S_S^{ED} . As a result, the firm with a pension surplus will choose a higher level of debt at a lower bond spread.

Suppose, instead, the firm has a pension deficit. First, consider the firm's supply of external debt. This firm does not have to repay pension liabilities in bankruptcy, and the pensioners do not charge higher payments when the firm is solvent to internalize that cost to the firm. As a result, the chance of bankruptcy – which rises with total leverage – is more attractive, and the supply curve shifts to the right, from S^* to S_S^{ED} . Next consider investors' demand for the firm's debt. When the firm holds pension debt, it faces a stronger incentives to make investments that are riskier than socially optimal because the pensioners – not the shareholders or managers – pay the downside risk. As a result, the firm will make riskier investments. External lenders understand this incentive and correctly predict that the firm assumes more investment risk, decreasing lenders' expected return at any given interest rate. Lenders, accordingly charge higher interest rates for high leverage levels, rotating the demand curve upward to D_D^{ED} . Yet these higher interest rates do not fully reflect the increased agency cost due to pension debt; pensioners absorb much of that risk. In Figure 2.2(d), the firm with positive pension debt maintains a higher leverage ratio than it would without a pension, but also faces a higher spread, $r^d - r_{safe} > r^* - r_{safe}$.

This exposition relies on several assumptions. First, it assumes that pension leverage and external leverage have the same impact on the tax benefits of debt. Second, it assumes that there are no agency problems between the manager and the stockholder; as a result,

there are no agency benefits to debt. Finally, contrary to the inside debt theory, it supposes that managers do not internalize low pension payouts received in bankruptcy.

2.3.5 Bond Spread Patterns in Each Theory

Each theory described above has different predictions for the relationship between bond spreads and various types of leverage. Figure 2.3 takes two approaches to describing these relationships for firms with and without pensions. In each figure, the vertical axis represents the firm's equilibrium interest rate determined by the intersection of supply and demand for the firm's external debt. Figures 2.3(a) and (c) hold fixed the firm's total leverage ratio. Movements along the horizontal axis correspond to increases in pension relative to external leverage. Figures 2.3(b) and (d) allow total leverage to increase along the horizontal axis. In 2.3(b), external leverage increases while pension leverage remains fixed; in 2.3(d), pension leverage increases while external leverage remains fixed.

Figure 2(a) describes the interest rate in a firm without a pension. As pension leverage does not increase when the firm does not have a pension, the horizontal axis in this figure is perfunctory and included only to establish a comparison for the firm with a pension. Without a pension, the firm faces a bond spread of $r^* - r_{safe}$. Figure 2(c) describes the bond spread in a firm with a pension. Under the assumption that tax-free payments incurred by one dollar of pension and external debt are equivalent, the first two theories predict that pension and external debt are perfect substitutes. As a result, they predict a constant spread of $r^* - r_{safe}$ for all levels of pension relative to external leverage (red/green line).

The other two theories allow agency frictions to influence the supply and demand for the firm's debt as pension debt changes relative to external debt. The third theory (orange line) allows managers to have different agency relationships with their pensioners and external bond holders. If pension debt is considered inside debt, bond spreads fall with higher levels of pension leverage relative to external leverage: firms pay lower agency costs associated with external debt when they maintain higher pension leverage. The final theory (blue line) supposes that the agency relationship between managers and pensioners is similar to that between managers and bondholders. However, pension regulations prevent pensioners from effectively managing those agency problems. In this theory, higher pension relative to external leverage leads to higher spreads on external bonds: firms pay higher agency costs associated with external debt when they maintain higher pension leverage.

Figures 2.3(b) and (d) compare the relationship between external leverage and bond spreads to the relationship between pension leverage and bond spreads in each theory. Without a pension (Figure 2.3(b)), bond spreads rise as external leverage increases due

to higher bankruptcy risk and agency costs. Figure 2.3(d) compares this rise in spreads to the rise in spreads when pension leverage rises by an equivalent amount, keeping external leverage fixed. Again, the theory of pensions as a put option suggests that bond spreads rise at the same rate with pension leverage as they do with external leverage. Allowing for pension contributions to decrease the tax benefits of external debt (theory 2, green line), bond spreads rise slower with pension debt than they do with external debt until the tax benefits of debt are exhausted, when they begin to rise at the same rate. If managers internalize the bankruptcy payoff to pensioners but not external bondholders (theory 3, orange line), bond spreads rise at a slower rate with pension debt than with external debt. Finally, if managers have the same agency relationships with pensioners and bondholders, but pensioners do not have the full mechanisms available to internalize agency costs (theory 4, blue line), bond spreads will rise faster with pension debt than with external debt. Table 2.1 summarizes the main differences among the four theories.

Section 2.4 describes a group of publicly-listed firms with and without defined benefit pensions, while section 2.5 translates these simple predictions into two descriptive regressions. Figures (a) and (c) amount to holding total leverage fixed, but varying the percent of pension leverage relative to external leverage. Figures (b) and (d) suggest comparing the slope of bond spreads with respect to changes in pension leverage to that with respect to changes in external leverage.

2.4 Publicly-listed firms: Data description

This section uses two sources of data to explore bond spreads for publicly-listed firms with and without defined benefit pensions from 1990 through 2007. The sample analyzed excludes financial and utilities firms (SIC codes 6000 through 6999 and 4900-4999). Compustat, compiled from annual financial statements of publicly-listed firms, describes the general financial status of a firm and reports limited information on pension assets and liabilities. Deal Scan, a database of loans constructed by the Loan Pricing Corporation (LPC), describes characteristics of loans to large firms. The two datasets are linked using the Dealscan-Compustat Link Data, created by Michael Roberts, to investigate loan pricing for firms with and without pensions.⁴

⁴The Dealscan-Compustat Link data is freely available through the Wharton Research Data Center (WRDS) or on Michael Roberts' website: <http://finance.wharton.upenn.edu/mrrobert/styled-9/styled-12/index.html>. The data is initially described in Chava and Roberts (2008)

2.4.1 Sample selection

Table 2.2 describes selected balance-sheet indicators for firms with and without defined benefit pensions. Firms are classified as sponsoring defined benefit pensions in each year in which they report pension assets on their balance sheets. The full Compustat sample includes 13,012 firms, 2,944 of which report a defined benefit pension at some point between 1990 and 2007. This amounts to 97,601 firm-years with pensions and 37,617 firm-years without pensions.

This table presents the three types of leverage described above: total leverage, external leverage, and pension leverage.⁵ External leverage is the ratio of long-term debt to non-pension assets. The book value of total assets reported on the balance sheet includes adjustments for pension income and expenses reported on the cash-flow statement. The measure of non-pension assets considered here is calculated as book assets cleansed of these adjustments for pension income and expenses following Shivdasani and Stefanescu (2012). Pension leverage is the ratio of unfunded pension liabilities to non-pension assets, where unfunded pension liabilities is the projected benefit obligation less total pension assets, both reported in the footnotes of firms' 10-ks. To display the full variation, pension leverage is multiplied by 100 in Table 2.2. Publicly-listed firms with and without defined benefit pension supported similar total leverage ratios on average: .29 versus .27. At the median, however, total leverage was substantially higher among pension firms than non-pension firms: .25 versus .13. External leverage was lower at the mean and higher at the median among firms with pensions than without, suggesting that the distribution of external leverage among firms with pensions was more concentrated than the distribution among firms without pensions. Pension firms face an average surplus in their pension accounts of 1.8 percent of total non-pension assets. The fact that total leverage is similar to external leverage reflects the fact that pension debt is small relative to external debt. Firms with defined benefit pensions in the full Compustat sample tend to be more likely to be rated, larger, have more tangible assets, lower market-to-book ratios, and lower profitability than their counterparts without pensions.

Deal Scan, a database of loan facilities viewed at their issuance date, describes spreads firms face on corporate bonds. Deal Scan covers between 50 and 75 percent of all commercial loans issued between 1988 and 2009 (Bharath, et al., 2009). Included loans can be classified as long-term loans, short-term loans, or standard lines of credit according the Deal Scan description of loan type. The ultimate sample includes 261,428 loans issued from 1990 through 2007. The last column of Table 2.2 describes these loans: overall, these

⁵Appendix A describes variables and the procedure used to clean balance sheet data of pension assets.

loans had an average loan amount of \$195 million, and average maturity of 57 months. Seven percent were rated, 18 percent secured, and 45 percent long-term loans. The main outcome variable of interest in this study is the “all in drawn spread” provided in Deal Scan. This variable, referred to as $\text{Spread}_{i,ft}$ throughout this paper, is the mark-up on the loan over the market interest rate that matches the loan maturity (such as LIBOR). The average spread on the long-term and short-term loans in the sample is 227 basis points, while the median is 225 basis points.

The linked sample includes 47,832 unique facilities, 23,300 of which are issued by firms without pensions and 24,532 of which are issued by firms with pensions. This amounts to 23,156 firm-years in total, 11,192 of which are issued to firms sponsoring pensions. Table 2.2 compares main firm and loan-level characteristics of the matched and unmatched data for defined benefit and non-defined benefit firms. The differences between pension and non-pension firms described earlier are not as striking in the matched data as in the full Compustat sample. Pension and non-pension firms have similar levels of total and external leverage in the matched sample. Pension leverage, external leverage, and total leverage are all higher, on average, than the full Compustat sample. Matched pension and non-pension firms are also more similar in terms of tangibility and market-to-book ratio than in the full Compustat sample.⁶ The matched facilities for non-DB firms are similar in maturity but tend to be smaller in amount and have higher spreads, on average, than those facilities matched in DB firms. This is consistent with the finding that matched non-DB firms tend to be smaller than matched DB firms. The next section controls for a variety of firm and facility-level factors, other than differences in leverage, that could account for this systematic difference in bond spread.

2.4.2 Sample characteristics

Table 2.3 describes firm and facility characteristics of the main analysis sample in 1990, 1998, and 2007. The bond spread (Spread) is the facility-level outcome variable of interest in the analysis below while the various leverage ratios are the explanatory variables of interest. Consistent with the fact that non-pension firms tend to be smaller than pension firms, they also face higher bond spreads overall. In 1990, non-pension firms faced an average spread of 263 basis points – 40 percent higher than the average spread facing pension firms (189 basis points). This difference maintained throughout the sample period, though bond spreads fell for both types of firms. This difference in spreads may be a result of consistent differences between the two types of firms (firm size, market-to-book ratio).

⁶As Deal Scan covers mostly large loans, so the link matches the largest of both defined benefit and non-defined benefit firms.

Alternatively, it could be a result of different firm behavior due to their respective capital structures.

The table reflects a general pattern of rising pension debt in the U.S. economy. Average pension leverage increased among pension firms in the matched sample, from .07 percent of firm assets to 1.29 percent of firm assets, between 1990 to 2007. The median level of pension obligations increased from 25 to 281 billion over this time. The basic trends presented in this table show some evidence that pension firms may have maintained similar levels of total leverage by decreasing non-pension debt over this period. Prior to 2007, both pension and non-pension firms maintained similar levels of non-pension debt. By 2007, pension firms had lower levels of external debt and total leverage than their non-pension counterparts. Figure 2.4 reinforces the pattern of rising pension burden. This figure shows a scatter plot of pension leverage versus total leverage in 1990, 1998, and 2007. While total leverage ratios were largely similar across these three years, pension leverage was more likely to be positive in 2007 than in 1990 or 1998. In 2007, in fact, most firms had pension deficits.

Figure 2.5 compares the distribution of two measures of leverage – external and consolidated – aggregated over three illustrative categories of support for all publicly-listed firms that sponsor and do not sponsor defined benefit pensions in 1990, 1998, and 2007. The graphs on the left (a,c,e) plot the ratio of external debt to non-pension assets while the graphs on the right (b,d,f) plot the ratio of total long-term debt (external and pension) to total assets (on-balance sheet and pension). Each bar represents the fraction of pension (navy bars) or non-pension (light blue bars) firms with leverage ratio in one of the following categories: equal to zero, above zero but below .5, and over .5. These figures suggest that the aggregate distribution of the external debt ratio is more concentrated among firms with pensions: in 1990, for example, DB firms are seven percent less likely than their non-DB counterparts to hold zero debt and 10 percent less likely to hold debt ratios above .5. Consolidated leverage ratios among pension firms are similarly more concentrated than leverage ratios among non-pension firms. The graphs on the right show that pension firms are between eight and 30 percent less likely to have zero debt, and between zero and five percent less likely to have debt ratios above .5, once pension liabilities are taken into account in 1990. A similar pattern arises within industry – in industries in which defined benefit pensions are common (manufacturing and transportation), and in industries in which defined benefit pensions are less common (services and retail trade).

Table 2.3 also describes firm-level and facility-level variables that are often considered to influence the cost of debt. Non-pension firms tend to be smaller with higher book-to-market ratios than their counterparts with pensions, though both types of firms grow from

1990 to 2007. Non-pension and pension firms have similar levels of tangibility, interest coverage, and distribution of current assets. Throughout the sample, non-pension firms are less likely to be rated. In 1990, non-pension firms took out smaller loans at shorter maturities than firms with pensions. This difference in maturity declined by 2007, but the difference in loan size remained.

2.5 Empirical tests for each theory of borrowing rates

This section lays the empirical groundwork to describe the basic relationship between spreads and three types of leverage – total leverage, pension leverage, and external leverage. The two specifications explored in sections 2.5.1 and 2.5.2 reflect the graphical expositions in Figures 2.3(d) and (c), respectively. Strahan (1999) describes the standard issuance-level regression to investigate the determinants of bond spreads:

$$\text{Spread}_{i,ft} = \beta \text{Leverage}_{it} + \gamma \text{Facility Controls}_{i,ft} + \mu \text{Firm Controls}_{it} + \delta_j + \delta_t \quad (2.1)$$

In specification 3.1, i indexes the firm, f indexes the debt issuance, j indexes the industry, and t indexes the year the facility was issued. Facility controls include the loan amount, maturity, and an indicator for whether the loan is secured. Lenders often use these characteristics of the loan contract, in concert with the spread, to manage agency problems with the lender. Larger loans with higher maturity tend to have lower spreads, as lenders are willing to lend more to firms with less bankruptcy risk (Strahan, 1999). Secured loans also face lower spreads. Firm controls include firm size, profitability, tangibility, market-to-book ratio, interest coverage and ratio of current assets to current liabilities.

Two variables are of particular interest in testing the predictions of the theories laid out in the previous section: the issuance-level spread, $\text{Spread}_{i,ft}$, and the firm-level leverage, Leverage_{it} . In the traditional specification, β is predicted to be positive: a firm faces a higher spread over the risk-free rate for new debt issues when it has higher leverage. In a contingent-claims framework, higher leverage increases the probability of bankruptcy and, therefore, the rate of return an investor requires to break even. Several papers, measuring leverage as balance sheet leverage, highlight that this basic regression does not capture all variation in bond spreads (Collin-Dufrense, et al., 2001; Huang and Huang, 2012; Strahan, 1999). This paper adds to that literature by exploring whether the composition of total debt is informative.

Table 2.4 describes the results from specification (3.1) using five different measures of leverage: net leverage, consolidated leverage, total leverage, external leverage, and pen-

sion leverage. All columns restrict the regression to long-term debt facilities. The first five columns present the results from specification (3.1) without modification, while the last three columns include the log magnitude of pension liabilities in the regression of spreads on various measures of leverage that account for pension debt. In all cases, as expected, the spread rises with leverage. An increase in the net leverage ratio from 0 to 1 translates to an increase in the long-term spread of 23 basis points. An interpretation of this coefficient that is, perhaps, more realistic suggests that a 10 percentage point increase in balance-sheet leverage is associated with an increase in the long-term spread of 2.3 basis points. The coefficient estimates on external leverage and total leverage, columns (2) and (3), are statistically similar to this estimate on net leverage. The coefficient estimates on consolidated and pension leverage, on the other hand, are both statistically higher; spreads increase by 3.82 basis points when consolidated leverage increases by 10 percentage points, and by 22.4 basis points when pension leverage increases by 10 percentage points (columns 4 and 5).

The higher estimates associated with measures of leverage that account for pension debt could reflect a variety of factors, including the theoretical relationships described in the previous section. One factor associated with the pension account that could influence spreads but is not captured by those theoretical relationships is the magnitude of pension liabilities. Firms with the same amount of unfunded pension liabilities may have different levels of total pension obligations. Conditional on the level of unfunded liabilities, higher total pension obligations will impose more risk on debtholders: firms with more total pension obligations will face higher future unfunded pension liabilities if they suffer percentage declines in the market value of pension assets. The higher coefficients on the leverage measures in models (1-Net) and (4-Consolidated) support the hypothesis that pension obligations introduce this additional risk.⁷ The theoretical relationships described above, however, abstract from this dimension of risk associated with the pension account and focus on the difference between pension and external leverage. Empirical tests of those relationships, therefore, must control for risk associated with the magnitude of pension liabilities and distinguish pension and external leverage.

Models (6) through (8) explore the impact of controlling for total pension obligations on leverage coefficient estimates in Table 2.4. Reflecting the potentially non-linear relationship between the magnitude of pension obligations and risk incurred, these models include the log value of pension obligations. The magnitude of pension obligations is positively

⁷In fact, these differences highlight one of the key arguments for using consolidated rather than net leverage to capture risk introduced by pension accounts (Shivdasani and Stefanescu, 2012): consolidated leverage captures the risk introduced by exposure to asset market fluctuations through the pension account.

correlated with spreads in models (6) through (8), but the impact of including pension obligations on the coefficient estimate of leverage differs slightly in each model. In model (6), a ten percent increase in pension obligations is associated with a 7.4 basis point increase in spread, but the coefficient on total leverage does not differ between models (3) and (6). In these models, the coefficient on total leverage is primarily identified with variation in external leverage, rather than pension leverage. The average ratio of pension to external leverage among firms with pensions is .08; pension leverage is a much smaller component of total leverage than external leverage. In model (7), a ten percent increase in pension obligations is associated with a 6.5 basis point increase in spread, and the coefficient on consolidated leverage is 2 basis points smaller in model (7) than in model (4). Consolidated leverage captures both pension debt (unfunded pension liabilities) and risk due to the exposure to asset market fluctuations (total pension obligations). Separately controlling for pension obligations therefore decreases the coefficient estimate on consolidated leverage, bringing it more in line with coefficient estimates on total or external leverage. In model (8), a ten percent increase in pension obligations is associated with a 5.6 basis point increase in spread, and the coefficient on pension leverage is 13 basis points smaller in model (8) than model (5). Again, pension leverage includes variation in both pension debt and market exposure due to the magnitude of pension obligations; as a result, controlling for total obligations decreases the coefficient estimate on pension leverage. The specifications in the following subsections control for log pension liabilities so that coefficients on leverage are primarily identified with variation in external and pension leverage, rather than market exposure through the pension.

Despite the decidedly stronger relationship between pension leverage and spreads than between external leverage and spreads, pension leverage is a much smaller component of total leverage. A firm in the 90th percentile of pension debt maintains a pension leverage ratio of .08, while a firm in the 95th percentile of external leverage maintains a external leverage ratio of .87. Figure 2.6 compares the impact on spreads of moving from the 25th to 75th percentile of pension and external leverage. A pension firm that increases its pension leverage from the 25th to 75th percentile (from a surplus equal to 2 percent of non-pension assets to a deficit equal to 2 percent of non-pension assets) increases their bond spread by 8.68 basis points. This is equivalent to a 5.5 percent increase in spread for a pension firm with the average spread in 2007. A pension firm that increases its external leverage from the 25th to the 75th percentile (from 16 to 41 percent of total assets) would increase its spread by 6.45 basis points, or 4.1 percent of the average spread in 2007. Therefore, while an increase in pension leverage is associated with a increase in spread about 9 times larger than an equivalent increase in external leverage, the overall impact of pension leverage

and external leverage on spreads are much more comparable. The differential impact of equivalent levels of pension and external debt, however, suggests that external investors do not equally value the two types of leverage. With this in mind, the next subsection turns to some more direct comparisons of the relationships among pension leverage, external leverage, and bond spreads.

The graphical analysis in section 2.3.5 suggests two modifications of this regression to distinguish the relationship between pension debt and bond spreads. Figure 2.3(d) suggests comparing the change in bond spread associated with a change in pension debt to the change in bond spread associated with an equivalent change in external debt. Figure 2.3(c) suggests looking at the change in bond spread as pension leverage increases relative to external leverage, when the firm's total leverage ratio is fixed. The following subsections consider these specifications in turn.

2.5.1 Specification 1: Direct comparison of response to pension leverage and external leverage

The following modification of specification 3.1 compares the relationship between external debt and bond spreads with that between pension debt and bond spreads.

$$\begin{aligned} \text{Spread}_{ift} = & \beta_1 \text{External Leverage}_{it} + \beta_2 \text{Pension Leverage}_{it} + \alpha \text{Pension Obligations}_{it} \\ & + \gamma \text{Facility Controls}_{ift} + \mu \text{Firm Controls}_{it} + \delta_j + \delta_t \end{aligned} \tag{2.2}$$

The put-option model of pension leverage predicts that the well-documented positive relationship between balance-sheet leverage and bond spreads will also exist between pension debt and borrowing rates. Further, if pension leverage incurs the same level of tax-free payments and does not encourage managers to choose investments differently than they would with an equivalent level of external leverage, the coefficients on pension debt and external debt in specification 3.2 should be equal: $\beta_1 = \beta_2$.

However, two other theories presented in this paper – (3) pension debt as inside debt and (4) pension debt as external debt – suggest that, taking into account regulatory incentives and agency relationships associated with a pension account, pension leverage will induce a different behavioral response among managers than external leverage. If the pension debt aligns managers interests with bondholders, and the incentives associated with this inside debt and the tax benefits of debt dominate, then $\beta_2 < \beta_1$: pension debt corresponds to a smaller increase in spread than external debt. The firm with higher inside debt associated

with the pension will make investment decisions more in line with the interest of the lender and, therefore, face lower agency risk and spreads. Alternatively, if managers view pension debt similarly to external debt but respond to the different regulatory incentives associated with pension debt, then $\beta_2 > \beta_1$: pension debt corresponds to a larger increase in spreads than external debt. The firm with more pension debt, the payments of which do not internalize the downside risk to their investments, will make riskier investments, leading to higher agency risk and higher spreads.

Models (1) through (5) in Table 2.5 explore this specification for spreads on long-term bonds. Each model includes industry and year fixed effects, the facility and firm controls described in the previous section, and log pension obligations. Model (3) estimates that a 10 percentage point increase in external leverage, or 31 percent of the average external leverage among pension firms in 2007, is associated with a 2.7 basis point increase in spread. This is equivalent to an increase in spread of 1.2 percent for a firm facing the average long-term spread among pension firms in 2007. An analogous 10 percentage point increase in pension leverage, or 800 percent of the average pension leverage among pension firms in 2007, leads to a 21.7 basis point increase in bond spread, or 9.7 percent of the average spread among pension firms in 2007. The correlation between pension and external leverage is potentially large. Models (1) and (2) test the relationship between these measures and bond spreads separately and find similar coefficient estimates, suggesting limited bias in Model(3). In Model (5), the coefficient on the interaction term between external leverage and an indicator of whether the firm sponsors a defined benefit pension is insignificant, suggesting that bond spreads respond the same to external debt in pension firms as they do in non-pension firms. This supports the argument that the impact of structural differences due to sample selection on coefficient estimates associated with leverage are small.

A higher response in bond spreads to pension debt relative to external debt supports the agency theory that managers view pension debt as similar to external debt rather than inside debt. It does not, however, rule out that pension contributions lower the tax benefits of debt and contribute toward lower bond spreads. Model (4) interacts external leverage with pension leverage, and shows that the stronger role of pension debt dominates at high levels of external debt. Tax benefits of debt are smaller when firms have higher levels of leverage. Also, firms with higher leverage likely have stronger agency problems initially: with higher levels of external debt, firms face a higher chance of bankruptcy and a stronger incentive to make risky investments. Pension debt, in the fourth theory, magnifies existing agency costs of debt.

2.5.2 Specification two: Examination of the behavioral response

Figure 2.3(b) suggests that the four models of pension leverage and bond spreads can be distinguished by considering the impact of increasing pension leverage relative to external leverage, holding total leverage constant:

$$\begin{aligned} \text{Spread}_{ift} = & \beta_3 \text{Total Leverage}_{it} + \beta_4 \text{PctPenDebt}_{it} + \alpha \text{Pension Obligations}_{it} \\ & + \gamma \text{Facility Controls}_{ift} + \mu \text{Firm Controls}_{it} + \delta_j + \delta_t \end{aligned} \quad (2.3)$$

This specification assumes that the direct relationship between pension leverage and bond spreads is the same as the direct relationship between external leverage and bond spreads; echoing Modigliani-Miller (1958), the firm is indifferent among types of financing. However, agency relationships and regulations facing firms that sponsor defined benefit pension may encourage firms to make different investment decisions when their debt is tilted toward pension debt rather than external debt. PctPenDebt_{it} – the percent of all debt that is pension debt – captures the impact of those differences in investment decisions for pension and external debt on long-term spreads. In Modigliani-Miller (1958), $\beta_4 = 0$. If $\beta_4 > 0$, agency effects associated with outside pension debt dominate, encouraging firms to make riskier investments when their leverage ratios shift toward pension debt; if $\beta_4 < 0$, the agency effects associated with inside pension debt dominate, encouraging firms to make less risky investments when their leverage ratios shift toward pension debt.

Models (6) through (9) in Table 2.5 explore this specification in detail. Similar to previous estimates of the impact of external leverage on spreads, each specification shows estimates of β_3 between 26 and 30 basis points: a 10 percentage point increase in total leverage leads to an increase in bond spread between 2.5 and 3 basis points. Model (7) in Table 2.5 shows that $\beta_4 > 0$: increasing the percent of total debt that is pension debt by one percentage point would increase long-term spreads by 4.89 basis points. The average pension firm holds 8 percent of its total debt as pension debt; therefore, increasing the ratio of pension to total debt by 12.5 percent of the mean leads to a 4.89 basis point increase in long-term spread. Again, investment incentives consistent with the theory that pension debt is external debt with imperfect agency control mechanisms dominate. As in section 2.5.1, higher spreads associated with pension debt are primarily seen at higher levels of overall debt – levels at which agency costs are higher and tax benefits associated with debt are lower. Model (8), where the coefficient on the interaction between total leverage and percent of leverage that is pension debt is positive, presents this result. Further, total leverage, again, has the same relationship with long-term spreads for pension firms as it

does for non-pension firms (Model 9).

2.6 Agency costs and pension leverage: long-term versus short-term spreads

Both of the above tests are consistent with the hypothesis that the indirect effect of pension debt leads to higher bond spreads than non-pension debt: the external debt incentives dominate the inside debt incentives. This section explores, in greater detail, predictions associated with the theory that considers pension debt as external debt with imperfect agency control mechanisms.

The extent of the agency problem between lenders and borrowers influences the rate at which bond spreads rise with pension leverage. Firms with pension debt shift a portion of the downside risk associated with investments onto pensioners, encouraging those firms to make riskier investments than they would without pension debt. When the firm has more opportunities to make risky investments (non-contractible risk) –that is, higher agency cost without a pension – it will take on more investment risk than it would with lower non-contractible risk at an equivalent level of pension debt. While pensioners do not raise rates to reflect this risk, external lenders do. In this way, pension debt magnifies existing agency costs between a firm and its external lenders.

This theoretical dynamic suggests that borrowing rates should rise more quickly with pension debt when the existing agency costs between stockholders and bondholders are larger. One indicator of the level of agency costs between stockholders and bondholders is the maturity of the loan: due to the length of the exposure, long-term lenders assume more risk associated with bankruptcy than short-term lenders. Table 2.6 replicates the results from the cross-sectional regressions presented in Table 2.5, but including only short-term loan facilities in the sample. As described section 2.5.1, theory 4 predicts that $\beta_2 > \beta_1 > 0$: spreads on short-term bonds rise faster with pension debt than external debt. Further, as short-term debt is associated with lower agency risk, this theory predicts that the estimates of β_2 in Table 2.6 should be smaller in magnitude than those in Table 2.5.

Table 2.6 is consistent with these predictions. The positive association between short-term spreads and pension debt is stronger than that between short-term spreads and external debt: a ten percentage point increase in pension leverage is associated with an increase of 7.2 basis points in the bond spread, but an equivalent increase in non-pension leverage corresponds to an increase of only 2.2 basis points. This increase in short-term bond spread associated with a 10 percentage point increase in pension leverage is 5 basis points larger

than the increase in short-term bond spread associated with a 10 percentage point increase in non-pension leverage. In comparison, this difference is almost 20 basis points in Table 2.5. In the alternative interpretation captured by specification 2.3, the ‘behavioral response’ on short-term rates, captured in specification (8), is an increase of 13.1 basis points, rather than 48.9 basis points for long-term rates. These findings suggest that spreads associated with long-term bonds that have higher agency costs tend to be more responsive to pension debt relative to external debt than spreads associated with short-term bonds that have lower agency costs.

One potential concern arising from the comparison of long-term to short-term bond spreads is selection bias: perhaps short-term and long-term bonds are issued by fundamentally different firms. Strahan (1999) finds that lenders are, in fact, more likely to offer short-term loans to smaller firms with higher default risk. The shorter maturity requires firms to renew their bonds more frequently, allowing lenders to limit their risk exposure and strengthen their ability to monitor riskier borrowers. As a result of this phenomenon, agency risk associated with the long-term loan agreements in Table 2.5 and short-term loan agreements in Table 2.6 differs because of sample selection as well as loan maturity. The resulting differences in coefficient estimates associated with pension leverage reflect both proxies for agency risk.

2.7 Conclusion

This paper explores the relationship among pension leverage, external leverage, and bond spreads. Pension debt is a type of borrowing that firms can use to finance investments and, like traditional borrowing, requires payments throughout the lifetime of the loan. Previous literature has highlighted that exposure to market fluctuations through pension assets introduces risk in the level of pension payments defined benefit firms must make at any given time, and this risk induces higher spreads on new loans. This paper highlights another way in which sponsoring a defined benefit pension influences firms’ loan spreads: unfunded pension liabilities influence firms’ financing and investment incentives by introducing new agency conflicts and affecting tax burdens. Therefore, differences in spreads due to pension accounts also reflect differences in financing and investment risk.

This paper uses bond-level empirical analysis to show that pension leverage, separately from the magnitude of pension obligations, is associated with higher bond spreads than equivalent levels of external leverage. A 10 percentage point increase in pension debt is associated with a 22 basis point increase in bond spread, while an equivalent increase in external debt is associated with a 2.7 basis point increase in spread. Increasing pension

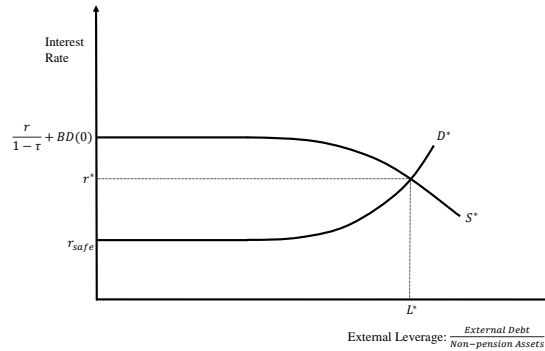
leverage from the 25th to 75th percentile increases long-term spreads by 8.7 basis points, while increasing external leverage from the 25th to 75th percentile increases long-term spreads by only 6.5 basis points – despite the fact that the increase in pension leverage would be much smaller than the increase in external leverage, as a percent of non-pension assets. This finding suggests that external lenders view pension debt to be significantly more risky than other external debt. This is consistent with a theory in which managers view pension debt as external debt rather than inside debt. While market mechanisms, such as bond covenants or maturity limitations, enable firms to lower agency costs associated with conflicts of interest between debtholders and stockholders, those mechanisms are unavailable to firms trying to lower agency costs associated with conflicts of interest between debtholders and pensioners.

In a decision representative of the burden that sponsoring defined benefit pension plans exerts on firms, General Motors offloaded \$26 billion worth of pension obligations by purchasing private annuities for 76,000 salaried employees in 2012. Many observers cite the payment risk associated with large pension obligations to be the motivating factor for this decision.⁸ This paper suggests that these pension obligations had a further cost: they increased the cost of external corporate debt. This increase in cost is due not only to payment risk, but also to changes in investment incentives associated with unfunded pension obligations. In the year that General Motors made this decision, pension firms maintained average unfunded pension liabilities equal to 6.3 percent of total non-pension assets. Estimates in this paper suggest that a firm with that level of pension debt could borrow externally to fully fund its pension and decrease its bond spread by 12 basis points, or 6.8 percent of average long-term spreads facing pension firms. Perhaps it was not only payment risk, but also decreases in the cost of corporate debt that encouraged General Motors to make the largest one-time annuity purchase in history.

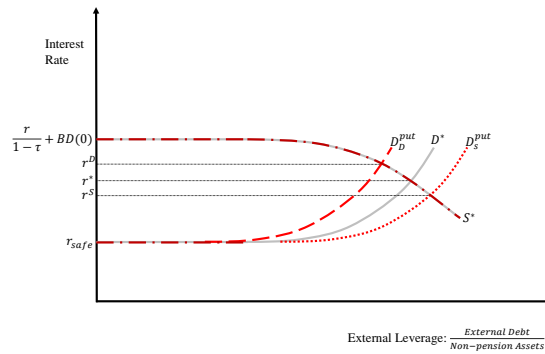
⁸See, for example, <http://www.pionline.com/article/20120822/ONLINE/120819895/mixed-opinions-on-gms-plan-to-transfer-29-billion-to-prudential>

Figure 2.1: Direct Effects of Pension Debt on the Supply and Demand for External Debt

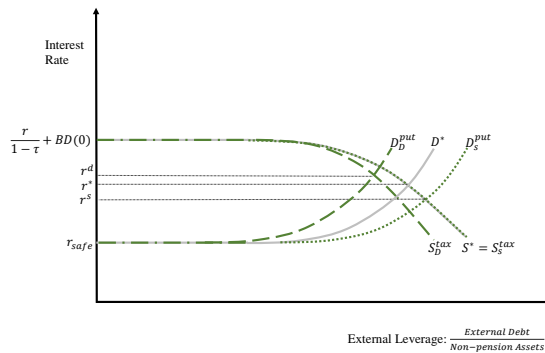
(a) Firm without Pension



(b) Pension Debt as Put Option

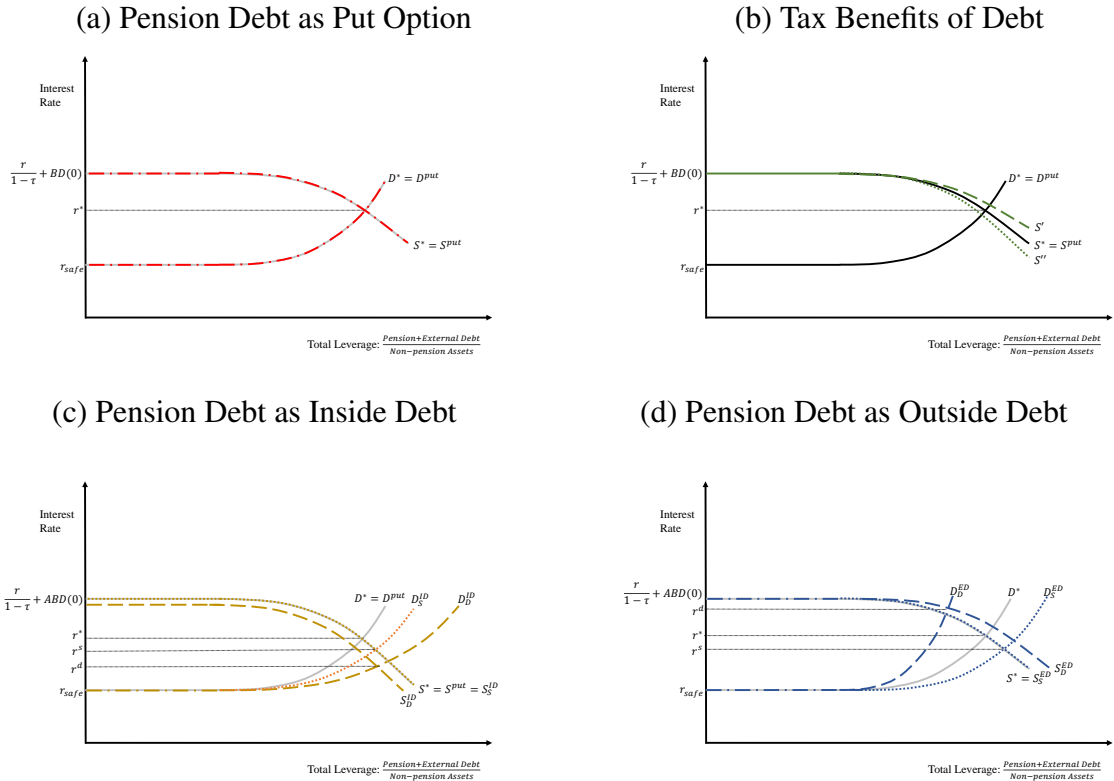


(c) Tax Benefits of Debt



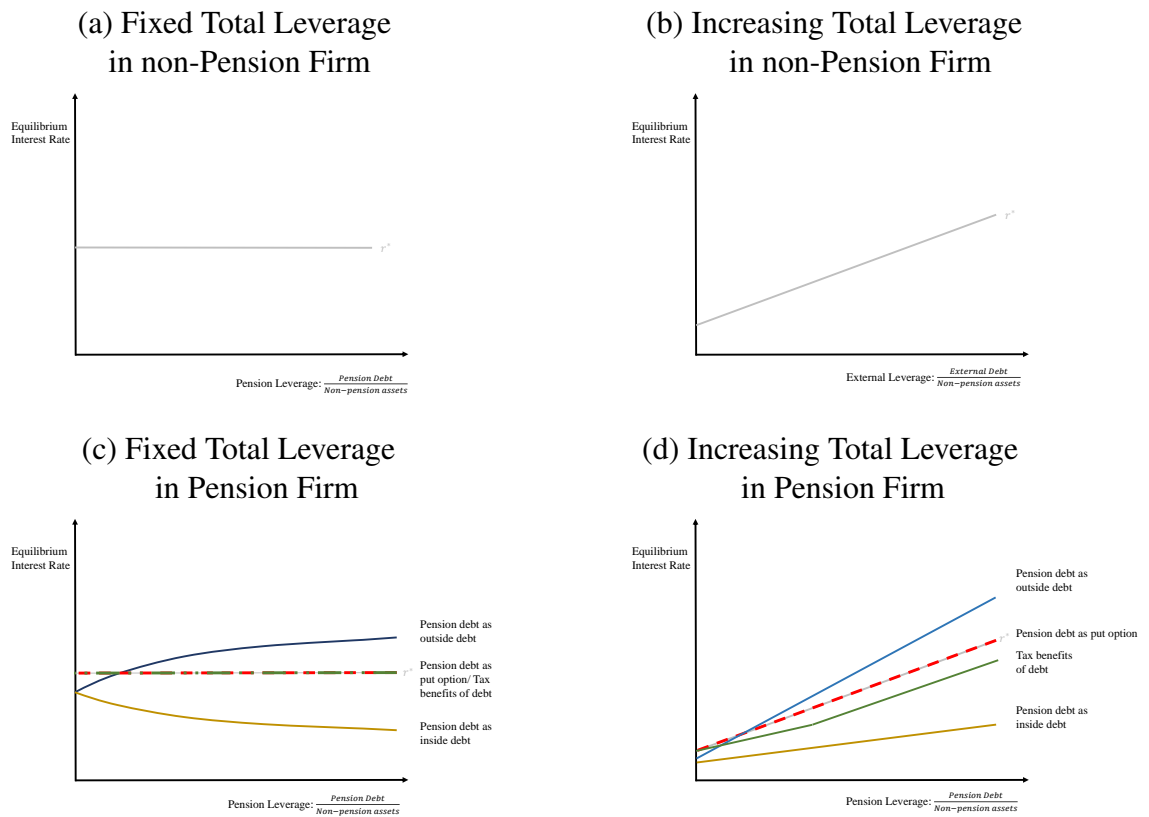
Notes. Figure shows supply and demand of debt for one individual firm. Interest rate (not risk-adjusted), on the vertical axis, is rate at which firms can take out new external loans. Total funds (external and pension debt plus equity) remains fixed, but external debt increases along the horizontal axis. S^* and D^* are supply and demand for the firm's debt when it does not sponsor a pension. r^* and L^* represent firm's interest rate and total leverage when it does not have pension. Colored lines are supply and demand of the firm's debt when it has a pension surplus (dotted) or a pension deficit (dashed), conditional on external debt. r^D and r^S represent the rates at which firm can issue new debt when it has a pension deficit and a pension surplus. $BD(x)$ refers to the agency benefits of debt when external leverage is equal to x ; benefits decrease in external leverage.

Figure 2.2: Indirect Effects of Pension Debt on the Supply and Demand for the External Debt



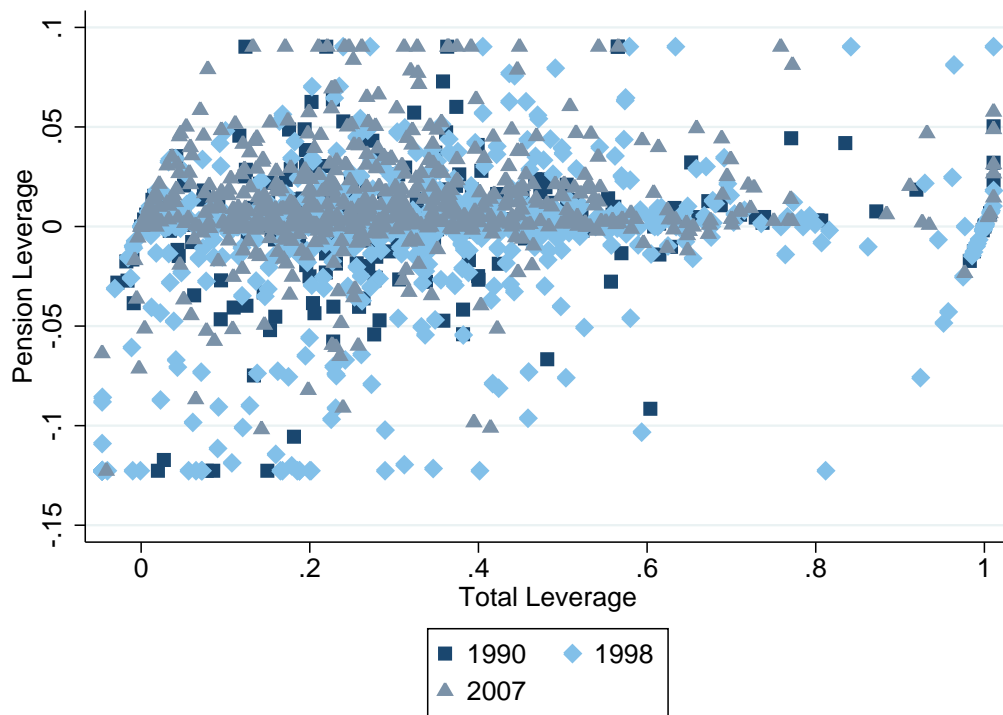
Notes. Supply of and demand for a firm's external for given level of total funds (External debt, pension debt, and equity), according to three theories. Firm's external debt ratio is on the horizontal axis and the return, not risk-adjusted, to the firm or lender is on the vertical axis, leading to an unconventionally upward sloping demand curve and downward sloping supply curve. Grey lines represent supply S^* and demand D^* for the firm's debt when it does not sponsor a pension: a firm without pension borrows at rate r^* . Dotted lines represent demand D_S^X and supply S_S^X for a firm's debt when the firm has a pension surplus. The superscript X refers to the theory of interest. Dotted lines represent demand D_D^X and supply S_D^X for firm's debt when it has low pension debt. The lines are dash-dotted where the supply or demand for debt in a surplus or deficit firm overlap.

Figure 2.3: Interest Rates Facing Firms With and Without Pensions



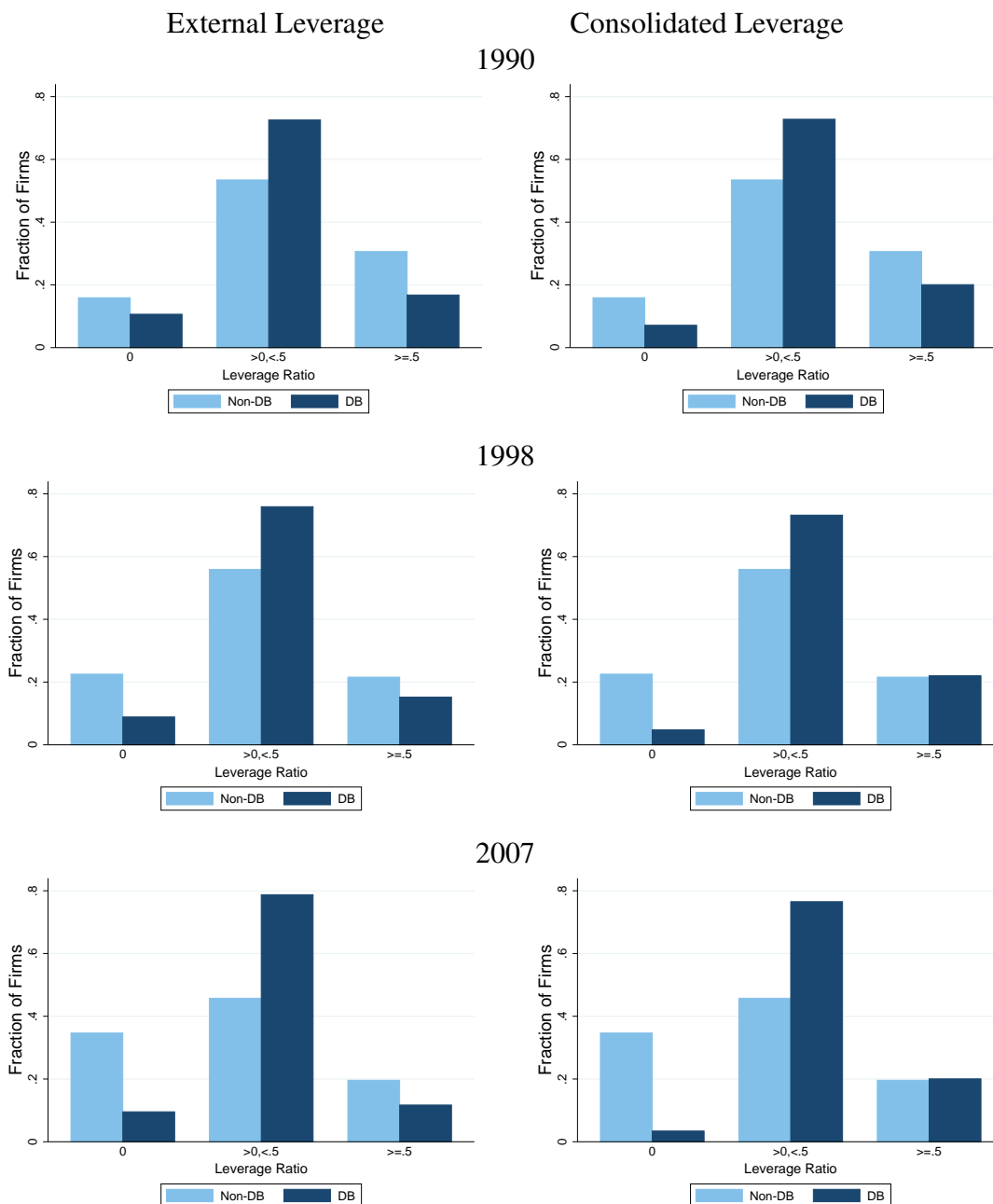
Notes. Describes the potential impact of sponsoring a defined benefit pension on a firm's external leverage and borrowing rate. Figures (a) and (c) assume that the total leverage ratio is fixed. In Figure (a), the composition of the firm's debt is constant because the firm does not have pension debt. In Figure (c), the firm's pension debt accounts for more of the firm's total debt moving along the horizontal axis. In Figure (b), external debt increases along the horizontal axis. In Figure (d), pension debt increases by the same amount along the horizontal axis, but external debt remains fixed. Graph (c) reflects the second specification while Graph (d) reflects the first.

Figure 2.4: Pension Leverage Versus Total Leverage in 1990, 1998, and 2007



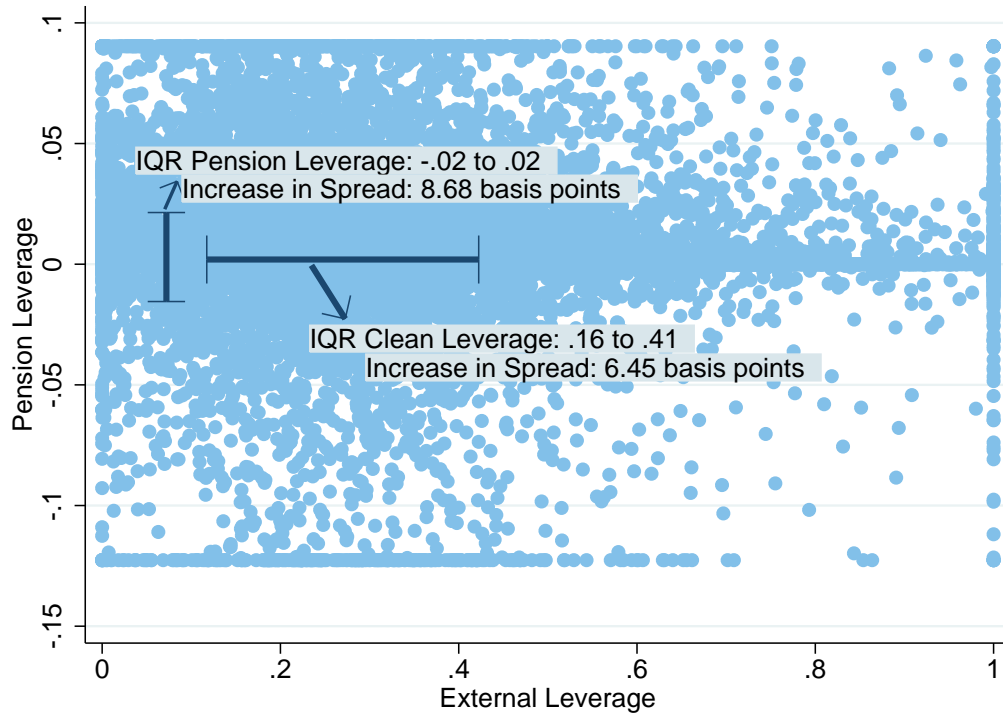
Notes. This figure is a scatter plot of pension leverage versus total leverage in four years for firms in the matched sample. Pension and total leverage are windsorized at the 1st and 99th percentile. Note that the range of the horizontal axis is larger than the vertical axis.

Figure 2.5: Leverage with and without a Defined Benefit Pension



Notes. DB firms are those that report defined benefit pensions in Compustat in (a,b) 1990, (c,d) 1998, or (e,f) 2007. Non-DB firms are those without a pension in Compustat in those years. Firms are separated into three categories based on their leverage ratio: (1) firms with zero debt, (2) firms with positive debt, but debt ratio less than .5, and (3) firms with debt ratio above .5. Figures (a), (c), (e) separate firms by their external debt ratio (external long-term debt to non-pension assets); figures (b), (d), (f) separate firms by their consolidated debt ratio (long-term debt plus pension liabilities to non-pension and pension assets). The height of the bars represents the percent of DB (dark bars) or non-DB (light bars) firms in each debt category.

Figure 2.6: Pension Leverage Versus External Leverage



Notes. Scatter plot of pension leverage versus external leverage for all firm-years in sample in which the firm sponsors a pension. Pension leverage and external leverage are windsorized at the 1st and 99th percentiles. Note that the range of the horizontal axis is smaller than the vertical axis. A firm at the 25th percentile of pension leverage maintains a pension surplus equal to 2 percent of non-pension assets, while a firm at the 75th percentile of pension leverage maintains a pension deficit equal to 2 percent of non-pension assets. If the firm moves from the 25th to 75 percentile of pension leverage, spreads increase by 8.68 basis points ($217 * (.02 - -.02)$). This amounts to an increase in the bond spread of 5 percent at the mean. A firm at the 25th percentile of external leverage maintains external debt equal to 16 percent of non-pension assets, while a firm at the 75th percentile of external leverage maintains external debt equal to 41 percent of non-pension assets. If the firm moves from the 25th to 75 percentile of external leverage, spreads increase by 6.45 basis points ($25.8 * (.41 - .16)$). This amounts to an increase in bond spread of 3.6 percent at the mean.

Table 2.1: The Impact of Pension Debt on Bond Spreads

	Type of Effect		Coefficient Predictions	
	Direct Effect	Indirect Effect	Pension Leverage Relative to External Leverage	Pct Pension Conditional on Total Leverage
Put Option	Yes	No	Equal	0
Tax Benefits	Yes	No*	Equal*	0*
Inside Debt	No	Yes	Lower	Negative
External Debt	No	Yes	Higher	Positive

Notes. Each Theory is described in Section 4. The direct effect of pension debt is described in Figure 2.1, while the indirect effect of pension debt is described in Figure 2.2. The Coefficient predictions are described in Figure 2.3 and tested in Table 2.5. * Under the assumption that each dollar of pension debt is leads to the same level of future contributions as each dollar of external debt leads to interest payments, then the theory that discusses the impact of pension leverage on the tax benefits of debt has no implication for the indirect effect of pension debt on bond spreads.

Table 2.2: Sample Selection from Compustat and Deal Scan Firms

	All Compustat		Both		All DealScan
	No Pension	Pension	No Pension	Pension	
Total Leverage					
Mean	.29	.27	.33	.32	
Median	.12	.23	.26	.28	
External Leverage					
Mean	.29	.27	.33	.32	
Median	.12	.23	.26	.29	
Pension Leverage $\times 100$					
Mean	0	-.18	0	.73	
Median	0	.09	0	.48	
Pension Obligations					
Mean	0	795	0	1448	
Median	0	28	0	109	
Firm Size ¹					
Mean	3.47	6.2	5.22	7.30	
Median	3.63	6.42	5.21	7.29	
Tangibility					
Mean	.27	.35	.32	.35	
Median	.17	.3	.23	.3	
Market-to-book					
Mean	3.66	1.87	1.97	1.64	
Median	1.67	1.35	1.45	1.38	
Profitability					
Mean	.24	.1	.12	.06	
Median	.13	.04	.05	.03	
Percent of Firms:					
Rated	6	24	20	35	
Bond Spread ²					
Mean			243	176	227
Median			250	150	225
Loan Amount					

Continued on next page

Table 2.2 – continued from previous page

	All Compustat		Both		All DealScan
	No Pension	Pension	No Pension	Pension	
Mean			161	376	195
Median			40	130	60
Loan Maturity					
Mean			48	50	57
Median			43	58	60
Percent of Facilities:					
Secured			60	40	18
Rated			23	44	7
Long-Term			31	27	45
N Facilities			23,300	24,532	261,428
N Firm-year	97,601	37,617	11,964	11,192	161,223
N Firms ³	12,942	2,944	4,572	2,255	39,733

Notes. This table describes all firms in Compustat with and without pensions (columns 1 and 2), all bond issuances in Deal Scan classified as long-term or short-term (column 5), and Compustat firms and matched Deal Scan bond issuances (columns 3 and 4). The two datasets are matched using the Compustat-Deal Scan link provided by Michael Roberts, described in Chava and Roberts (2008). Pension firms are those that report a pension on their 10-k; non-pension firms are those that do not report pension liabilities on their 10-k. The data appendix describes the construction of variables. (1) Firm size is reported in terms of log sales. (2) The bond spread is the all-in-drawn spread reported on Deal Scan: the spread over the term-relevant interest rate, reported in basis points. (3) The number of firms in Columns 1-4 is reported according to the Compustat identifier; the number of firms in column 5 is reported in terms of the Deal Scan identifier for borrower. The Deal Scan identifier for borrower is at a finer level of aggregation.

Table 2.3: Descriptive Statistics

	No Pension			Pension		
	1990	1998	2007	1990	1998	2007
<i>Spread</i>						
Mean	263	224	214	189	158	157
Median	255	225	190	150	150	125
IQR	205	125	130	218	188	175
<i>Long Term</i>						
Mean	299	252	275	217	228	222
Median	280	250	225	215	225	200
IQR	183	100	150	205	100	150
<i>Short Term</i>						
Mean	248	211	170	178	132	117
Median	255	200	150	125	100	88
IQR	230	143	125	205	160	140
<i>External Leverage</i>						
Mean	.39	.44	.42	.36	.4	.32
Median	.34	.39	.36	.32	.38	.29
IQR	.43	.49	.41	.27	.32	.26
<i>Pension Leverage ×100</i>						
Mean	0	0	0	.07	-.69	1.29
Median	0	0	0	.1	0	.55
IQR	0	0	0	1.75	1.25	2.09
<i>Firm Controls</i>						
<i>Firm Size</i>						
Mean	4.67	5.41	6.83	6.38	7	8.44
Median	4.64	5.4	6.68	6.32	6.94	8.34
IQR	2.21	2.49	1.9	2.67	2.46	2.35
<i>Pension Obligations (\$Bil)</i>						
Median	0	0	0	25	37	281
Mean	0	0	0	481	1,088	2,293
IQR	0	0	0	164	287	1,298
<i>Profitability</i>						

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Table 2.3 – continued from previous page

	No Pension			Pension		
	1990	1998	2007	1990	1998	2007
Mean	1.4	1.06	.96	1.26	1.09	.99
Median	1.16	.86	.72	1.08	.95	.85
IQR	.96	.95	1	.85	.71	.72
<i>Tangibility</i>						
Mean	.36	.31	.35	.38	.34	.3
Median	.29	.23	.25	.32	.29	.25
IQR	.37	.35	.54	.28	.28	.31
<i>Market-to-book</i>						
Mean	1.42	1.86	1.78	1.27	1.65	1.69
Median	1.19	1.39	1.46	1.11	1.31	1.45
IQR	.6	.92	.96	.46	.82	.76
<i>log Interest Coverage</i>						
Mean	1.52	1.52	1.76	1.44	1.76	2.09
Median	1.38	1.43	1.61	1.41	1.65	1.98
IQR	1.23	1.42	1.44	.96	1.03	1.32
<i>Current Ratio</i>						
Mean	1.86	2.22	1.99	1.88	1.72	1.6
Median	1.64	1.63	1.39	1.54	1.52	1.44
IQR	1.14	1.44	1.17	1.12	.91	.87
<i>Percent of Firms</i>						
Rated	15	28	42	43	59	70
Investment Grade	2	5	5	22	25	33

Facility Controls

<i>Loan Amount (\$ Mil)</i>						
Mean	46	123	400	178	298	865
Median	15	50	150	50	125	328
IQR	38	115	350	144	250	830
<i>Long-term</i>						
Mean	40	98	434	140	185	839
Median	8	30	165	37	100	300
IQR	23.44	95	345	106.98	171	750

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Table 2.3 – continued from previous page

	No Pension			Pension		
	1990	1998	2007	1990	1998	2007
<i>Short-term</i>						
Mean	49	133	376	192	336	880
Median	16	50	150	51	150	375
IQR	45	140	310	180	295	870
Loan Maturity (Months)						
Mean	45	55	58	60	55	58
Median	36	58	60	59	60	60
IQR	52	45	28	50	48	18
<i>Long-term</i>						
Mean	52	64	67	76	66	69
Median	53	61	72	68	70	71
IQR	46	41	24	42	26	24
<i>Short-term</i>						
Mean	42	51	51	55	51	53
Median	32	38	60	52	58	60
IQR	49	48	24	50	54	24
Percent of Facilities						
Secured	53	62	65	38	41	46
Long-term	27	28	41	25	25	37
N Firms	489	1120	551	345	749	645
N Facilities	865	2064	1016	644	1445	1250

Notes. This table describes the firms, facilities, and variables included in the regression presented in tables 2.4, 2.5, and 2.6 in 1990, 1998, and 2007. The full 1990-2007 sample includes 47,832 facility-years, 26,315 firm-years, and 3,046 firms. Bond spread, loan amount, loan maturity, and the percent of loans secured are from Deal Scan. All other variables are from Compustat. N firms is reported according to Compustat identifiers. Variable descriptions are available in the data appendix. Long-term facilities are those classified as term bonds and long term issuances by Deal Scan. Short-term facilities are those classified as short-term loans or lines of credit in Deal Scan.

Table 2.4: Response of Bond Spreads to Leverage

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DB=1	-6.05 (4.28)	-5.53 (4.27)	-6.31 (4.28)	-7.31* (4.3)	-7.41* (4.28)	-15.5** (6)	-15.2** (6.01)	-14.3** (6.03)
Net Leverage	23*** (8.9)							
External Leverage		24.8** (10.9)						
Total Leverage			26.3*** (9.09)			26.2*** (9.1)		
Consolidated Leverage				38.2*** (11.2)			36.4*** (11.2)	
Pension Leverage					224*** (80.1)			211*** (79.3)
Log Pension Liabilities						.742* (.386)	.647* (.385)	.564 (.386)
Firm Controls	X	X	X	X	X	X	X	X
Facility Controls	X	X	X	X	X	X	X	X
Observations	8117	8117	8117	8117	8117	8117	8117	8117
R^2	0.339	0.342	0.339	0.343	0.344	0.340	0.344	0.344

Notes. Standard errors, clustered at the firm-level, in parentheses; * $p < .10$, ** $p < .05$, *** $p < .01$. All regressions include year and industry fixed effects. The unit of analysis is the facility-firm-year. Firm controls include firm size, pension obligations, profitability, tangibility, market-to-book ratio, log interest coverage, current ratio, and whether the firm was rated or investment grade. Facility controls are loan amount, maturity, and an indicator for whether the loan was secured.

Table 2.5: External Leverage, Pension Leverage, and Spreads on Long-term Bonds

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DB=1	-15.6*** (6.03)	-14.3** (6.03)	-14.7** (6.01)	-14.7** (6)	-14.4* (8.43)	-15.5** (6)	-13.8** (6.01)	-13.2** (6)	-13.4* (8.09)
External Leverage	25.4** (10.9)		26.9** (10.9)	23.7** (10.9)	27.3** (13.9)				
Pension Leverage		211*** (79.3)	217*** (80.9)	47.8 (126)	217*** (81.1)				
External Leverage × Pension Leverage				584* (335)					
DB=1 × External Leverage					-.833 (16.8)				
Total Leverage						26.2*** (9.1)	29.5*** (9.37)	27.2*** (8.82)	30** (12.3)
Pct Pen Leverage							48.9*** (16.5)	24.4 (19.2)	48.9*** (16.6)
Total Leverage × Pct Pen Leverage								213** (104)	
DB=1 × Total Leverage									-.942 (14.5)
Observations	8117	8117	8117	8117	8117	8117	7939	7939	7939
R^2	0.343	0.344	0.345	0.346	0.345	0.340	0.347	0.348	0.347

Notes. Standard errors, clustered at the firm-level, in parentheses; * $p < .10$, ** $p < .05$, *** $p < .01$. All regressions include year and industry fixed effects. Sample is isolated to long-term loans, classified according to loan description available on Deal Scan. Firm controls are firm size, pension obligations, profitability, tangibility, market-to-book ratio, log interest coverage, current ratio, and whether the firm was rated or investment grade. Facility controls are loan amount, maturity, and an indicator for whether the loan was secured.

Table 2.6: External Leverage, Pension Leverage, and Spreads on Short-term Bonds

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DB=1	-5.28** (2.49)	-4.74* (2.5)	-5.23** (2.49)	-5.19** (2.49)	-5.05 (3.17)	-5.04** (2.51)	-5.24** (2.55)	-5.13** (2.54)	-7.18** (3.52)
External Leverage	21.6*** (5)		21.9*** (4.99)	21.3*** (4.98)	22.2*** (6.61)				
Pension Leverage		69.8*** (24.2)	71.8*** (24.5)	22 (40)	71.8*** (24.5)				
External Leverage × Pension Leverage				215* (127)					
DB=1 × External Leverage					-.6 (7.83)				
Total Leverage						28.8*** (5.89)	27.3*** (6.04)	25.7*** (6.21)	24.1*** (8.25)
Pct Pension Leverage							13.1*** (4.26)	10.2** (4.28)	13.6*** (4.3)
Total Leverage × Pct Pen Leverage								43.7 (31.1)	
DB=1 × Total Leverage									6.37 (9.19)
Observations	20445	20445	20445	20445	20445	20110	19383	19383	19383
R^2	0.565	0.565	0.566	0.566	0.566	0.564	0.569	0.569	0.569

Notes. Standard errors, clustered at the firm-level, in parentheses; * $p < .10$, ** $p < .05$, *** $p < .01$. All regressions include year and industry fixed effects. The sample is isolated to short-term loans, classified according to the loan description available on Deal Scan. Firm controls include firm size, pension obligations, profitability, tangibility, market-to-book ratio, log interest coverage, current ratio, and whether the firm was rated or investment grade. Facility controls are loan amount, maturity, and an indicator for whether the loan was secured.

CHAPTER 3

Defined Benefit Pensions and Firm Performance in the Great Recession

Many firms with defined benefit pensions experienced dramatic losses in the value of pension assets between 2007 and 2009 that led to high required pension payments. A general concern was that those payments prevented firms from making productive investments that could assist economic recovery. This paper suggests, instead, that pension losses allowed firms to borrow from their pensioners, while the credit crunch prevented those firms from taking on sub-optimally high leverage ratios and investment risk that are usually motivated by costly pensions. Indeed, firms making minimum required contributions from 2000 through 2007 supported leverage ratios that were 4.6 percentage points higher and default premiums that were 22 percent higher than their counterparts with less costly pensions. This wedge did not exist during the Great Recession.

3.1 Introduction

The value of employer-sponsored defined benefit pension plans fell by \$473 billion, or 25 percent, from 2007 to 2009.¹ Some firms that had maintained fully funded pension plans prior to the recession faced substantial pension deficits by 2008. General Motors, for example, supported a pension surplus equal to 6 percent of non-pension assets in 2007. By 2008, that surplus had disappeared, and the company faced a pension deficit equal to 22 percent of non-pension assets. Policy-makers, academics, and businessmen alike expressed concerns that required pension payments would divert cash flow from productive investments at time when the economy was in dire need of stimulus. This paper, however, suggests a more positive aspect of the pension losses and credit crunch during the Great Recession: pension losses allowed firms to borrow from their pensioners to support productive investments, while the credit crunch prevented those firms from taking on the sub-optimally high leverage ratios and investment risk that are usually motivated by costly pensions.

Between 2000 through 2007, defined benefit firms with costly pensions maintained higher leverage ratios and bankruptcy risk than firms with less costly pensions. During the Great Recession, defined benefit firms with costly pensions maintained the same leverage ratios and bankruptcy risk as firms with less costly pensions: they were avoiding risky positions that they might have taken before the recession. In this story, firms face costly pensions if contributing less to their pensions would induce high regulatory costs. This paper uses a unique regulatory characteristic to identify those firms: firms contributing at the legally required minimum have chosen a corner solution. They have particularly costly pensions because they would like to contribute less to their pensions, but face a very high cost of doing so. In pension-level data from the Department of Labor's Form 5500 linked to firm-level data available in Compustat, firms contributing at the legal minimum support leverage ratios that are 4.6 percentage points higher and default premia that are 22 percent higher than firms contributing above the minimum. This difference disappears during the Great Recession.

A theory of financing that incorporates pension regulations and conflicts of interest between stockholders and bondholders can explain these empirical patterns (Lay 2016a). Firms with defined benefit pensions can borrow from a unique type of lender: their pensioners. Regulations facing firms with defined benefit pensions create two characteristics of pension debt that influence firms' optimal capital structure and profile of investment risk over the business cycle. First, the structure of pension payments ensures that firms'

¹Pension Insurance Data Book (2014), Pension Benefit Guarantee Corporation. [http : //www.pbgc.gov/prac/data - books.html](http://www.pbgc.gov/prac/data-books.html)

equity holders will never internalize the full externality that their investment decisions impose upon pensioners. This encourages firms with pension debt to make riskier investments and, as a result, pay higher premiums on traditional debt: pension debt magnifies existing agency costs of external debt (Lay, 2016b). Second, firms can only borrow from pensioners by constraining contributions to under-funded pension plans. Among other regulations, legally required minimums prevent firms from taking assets out of pension plans. However, widespread market declines like those in 2008-2009 allow firms with previously well-funded pensions to borrow from their pensioners by constraining contributions. The Great Recession was associated with two other unique characteristics that influenced this dynamic: funding relief lowered the regulatory cost of constraining pension contributions and unprecedented tightness in the credit market made it particularly difficult for firms to borrow externally.

This theory predicts that firms with costly pensions borrow more to make pension contributions when external debt is cheap, but constrain borrowing at the expense of pension contributions when external debt is more costly. Contracting problems associated with pension debt lead to a pro-cyclical pattern in investment risk among firms with more costly pensions that mirrors this pro-cyclical pattern in borrowing. As a result, firms with costly pensions that make the riskiest investments during normal times will be more conservative during a credit crunch, and firms with less costly pensions during normal times may actually borrow from their pensioners to maintain productive investments, but avoid overly risky investments, during a credit crunch. This pattern may have been particularly strong during the 2000s due to regulatory and macroeconomic conditions that led to high cost pensions throughout the 2000s.

This paper is related to two strands of existing literature. First, several papers investigate determinants of leverage among firms (Rajan and Zingales, 1995; Frank and Goyal, 2007). This literature highlights the importance of firm characteristics that proxy for various aspects of agency cost in explaining firms' leverage ratios. Shivdasani and Stefanescu (2012) suggest that pension debt should also be taken into account when determining firms total leverage ratios. They argue for a consolidated measure of debt: the ratio of long-term debt and pension obligations to non-pension and pension assets. This paper suggests that pension debt may affect firms' choices of external leverage differently under different macroeconomic and regulatory conditions, and that it may be useful to measure the two types of debt separately.

This paper also sheds light on a recent empirical literature that exploits variation in minimum required pension contributions to speak to a long-standing debate on whether an observed correlation between cash-flow and investment levels indicates the presence of

financing constraints (Fazzari et. Al, 1988; Kaplan and Zingales, 1997). This literature uses differences in required pension contributions as exogenous variation in cash-flow to identify cash-flow effects on investment. Some of these papers use non-linearities in the formula used to calculate minimum required pension contributions as exogenous variation (Rauh, 2006; Bakke and Whited, 2012), while others use policy changes that decrease minimum required contributions between 2010 and 2014 (Dhambra, 2014; Kubick, et. Al, 2014). This paper argues that firms may respond differently to minimum required contributions in different macroeconomic environments, suggesting that policy changes that occurred during the Great Recession may not be valid instruments for cash flow.

Further, the paper speaks to the larger theoretical literature that motivates the search for instruments for cash-flow: cash flow influences investment in financially constrained firms when there is a wedge between the internal and external cost of funds. In highlighting that firms increase external borrowing to make minimum pension contributions, this paper emphasizes that pension regulation, conflicts of interest between stockholders and bondholders, and macroeconomic conditions interact to influence the wedge between the internal and external cost of funds. The extent to which this interaction influences that wedge depends on the regulatory cost of lowering pension contributions relative to the agency cost of external borrowing. Rather than using legal differences in minimum required contributions as an instrument for cash flow, as in Rauh (2006), this paper uses them as variation in the regulatory cost of lowering pension contributions.

This paper makes the argument that external borrowing and investment risk are pro-cyclical among firms with high pension costs in six steps. Section 3.2 describes the pension regulation and macroeconomic conditions that led to an environment in which pension obligations were particularly costly in the 2000s. Section 3.3 details the theoretical forces that encouraged a pro-cyclical pattern in borrowing and investment risk over that period. Section 3.4 describes testable empirical predictions from this theory, while section 3.5 describes the data and sample selection. Section 3.6 details the empirical specification used to identify the pro-cyclical trend, as well as the empirical results. Section 3.7 places those results in a broader context. Section 3.8 concludes.

3.2 Defined benefit pension obligations and regulations, 1975-2013

Figure 3.1(a) describes total employer contributions to private employer-sponsored defined benefit pension plans from 1975 through 2013, while Figure 3.1(b) describes the aggre-

gate funding status of those plans. Until the early 2000s, pension plans were significantly over-funded in aggregate, and contributions were limited in comparison to their magnitude after 2000. In 2000, the aggregate funding ratio in employer-sponsored pensions was 144 percent – that is, the market value of assets held in employer sponsored pension accounts was 144 percent of the present discounted value of their projected pension obligations. By 2003, the aggregate funding ratio had fallen to 85 percent. Over that same period, total contributions to employer-sponsored pensions increased five-fold, from \$20.8 billion to \$104 billion.

Both regulatory and macroeconomic conditions contribute to this pattern. In 1974, the Employee Retirement Income Security Act (ERISA) was enacted to regulate firms sponsoring defined benefit pensions. This regulatory framework includes the Pension Benefit Guarantee Corporation (PBGC), a public corporation that insures privately-sponsored defined benefit pensions, and a set of regulations that dictates how private firms manage their DB pension assets. In particular, this framework establishes a legally separate pension account, provides tax exemptions on contributions to and interest earned on assets held in the pension account for under-funded and moderately funded plans, and requires firms to maintain a minimum level of assets in the pension account to fund promised pension payments.

Macroeconomic conditions since 1974 have influenced firms' incentives to over-fund or under-fund their pension accounts within this regulatory framework. High interest rates in the late 1970s and early 1980s increased the attractiveness of the tax-break to pension contributions and returns, encouraging firms to maintain over-funded pensions. Yet asset price and interest rate declines in the early 2000s lowered the value of pension assets and increased the value of pension liabilities, creating large deficits in previously well-funded pension accounts. Continued low interest rates and large deficits created high minimum required contributions throughout the 2000s.

Changes to pension legislation post-ERISA have also contributed to the trends highlighted in Figure 3.1. Policy makers, responding to large pension surpluses in the 1980s, established an excise tax on the distribution of excess pension assets to plan sponsors. The excise tax increased from 10 percent in 1987 to 50 percent by 1990, discouraging firms dramatically from holding excess funds in their pension account. As low contributions and falling funding ratios of the 1990s suggest, many firms decreased pension surpluses in response to these regulatory changes by allowing pension obligations to accumulate without equivalent increases in pension assets.

As a result of this response, firms met the asset price and interest rate declines of the early 2000s with lower funding ratios than they might have absent these regulatory changes.

Funding ratios reached a post-ERISA historical low and contributions a historical high in 2003. By 2007, high asset returns and stricter pension funding requirements issued by the Pension Protection Act of 2006 led to an aggregate funding ratio over 100 percent, with the median plan-level funding ratio at 95 percent. Asset price and interest rate declines from 2007 to 2009, however, had a similar impact on pension funding status as declines earlier in the decade: the aggregate funding ratios returned to 80 percent in 2009 and contributions increased to \$114 billion. Historically high contributions of over \$100 billion from 2010 through 2012 coincided with funding ratios that continued to fall. The aggregate funding ratio in 2012 set a new historical low of 72 percent.

During the Great Recession, several relief packages were passed to decrease the contribution burden facing firms struggling to make minimum required contributions. The Funding Relief Act of 2010 allowed firms to temporarily decrease their minimum required contribution for 2009 through 2012. Further, in an effort to increase taxable corporate income, bipartisan budget acts from 2012 through 2014 have decreased minimum required contributions yet further. What was initially a temporary decrease in minimum required contributions could become more permanent, leading to consistently lower regulatory costs to lowering pension contributions.

3.3 Contracting problems introduced by pension regulation

The pension account can be considered a wholly owned subsidiary of the firm; as such, reductions in pension value due to declines in asset prices or interest rates should pass through to the firm. Sponsoring a pension in the presence of certain frictions may encourage firms to make behavioral changes in borrowing and investment that indirectly influence firm value. This section describes one such friction: pension regulations create contracting problems that magnify agency costs arising from conflicts of interest between stockholders and external debtholders. The extent to which this friction influences firm value depends on the regulatory cost associated with lowering pension contributions relative to the agency cost of borrowing more to make those contributions. When macroeconomic fluctuations change this relative cost, firms will adjust both their external leverage ratio and their profile of investment risk.

Firms with defined benefit pensions face two sources of borrowing: they can borrow externally by issuing external debt, or they can borrow from pensioners by making lower pension contributions than required to maintain a fully funded pension account. External

debt refers to both corporate bonds and bank debt; bondholders and banks set borrowing premia that reflect the cost of the overly-risky investments the firm would make so that, in expectation, they recoup the opportunity cost of the funds they lend. The adjective “external” distinguishes debt held by bondholders and banks, that use such traditional market mechanisms to address the agency problem between firms and their lenders, from debt held by pensioners. Pensioners manage contracting problems associated with non-contractible risk in a fundamentally different way: they limit the extent of pension debt with minimum funding requirements and depend on a government-sponsored insurance agency to provide payments if their firm enters bankruptcy with an underfunded pension account. Neither the minimum funding requirement nor the insurance premium depend on the firm’s profile of investment risk.

3.3.1 The mechanism through which pension debt magnifies agency cost

A key difference between external and pension debt is that pension debt payments are determined independently of the additional investment risk the firm imposes on its lenders while external debt payments are not. This characteristic of pension debt implies that defined-benefit firms that borrow from pensioners avoid internalizing the full agency cost associated with non-contractible production risk. Traditionally, firms pay this agency cost through higher bond spreads that internalize the externalities of risky investments imposed upon lenders in bankruptcy. However, while bondholders have full information and are aware that firms with pension debt will make riskier investments than firms without pension debt, they also share bankruptcy liability with pensioners. As a result, bondholders raise premiums only enough to reflect the investment risk imposed on bondholders – not pensioners – in bankruptcy. A firm with pension debt will pay higher borrowing premiums than an equivalently positioned firm without pension debt because it faces stronger incentives to make riskier investments, but those premiums do not internalize the downside consequences imposed on pensioners in bankruptcy. In this way, the interaction between pension regulations and conflicts of interest among stakeholders provides the firm a source of financing – pension debt – that does not internalize the consequences of overly-risky investments.

When large unfunded pension liabilities allow firms to avoid the full cost associated with bankruptcy, those firms support higher leverage positions that lead to higher bankruptcy risk: external debt is more attractive relative to equity as a form of financing. The amount of external debt those firms take on determines both the amount they have available to dis-

tribute between investments and pension contributions, and the spread they face on external bonds. Therefore, defined benefit firms with pension deficits face a trade-off when deciding how much to borrow. Borrowing more allows them to make higher pension contributions, and higher pension contributions reduce the regulatory cost associated with the defined benefit pension. Yet to make those higher contributions, firms must borrow externally at rates that increase with their leverage ratios and agency costs. As a result, firms can take on more external debt and contribute more to their pensions, but make riskier investments and face higher bond premiums; or they can constrain the amount of external debt they take on and make fewer risky investments, but contribute less to pension accounts and face higher regulatory pension fees. Thus, the key factor determining how much firms with unfunded pension liabilities borrow is the regulatory cost they face of contributing less to their pensions relative to the agency costs associated with higher external leverage.

3.3.2 Pension regulation

Pension regulations influence this relative cost by directly affecting the regulatory cost of contributing less in several ways. First, PBGC insurance premiums and minimum required contributions are increasing functions of the magnitude of unfunded pension liabilities, and often increase the cost of contributing less to under-funded pensions: lower pension contributions lead to higher future pension deficits and, in turn, higher future insurance premiums and minimum required contributions. A tax exemption on pension contributions and returns earned on assets held in the pension account may also increase the cost of contributing less to the pension: lower pension contributions imply more taxable corporate income. On the other hand, the excise tax and removal of the tax exemption for plans that are over 150 percent funded may decrease the cost to contributing less for firms that sponsor well-funded pension plans: firms with pension plans funded near or over 150 percent may be less motivated to contribute because those contributions are not exempt from the corporate tax, and firms must pay an excise tax of 50 percent on any surplus pension funds they revert. Finally, congressional changes in minimum required contributions or pension funding relief can influence the cost of contributing less. Over the period 2008-2013, three different congressional acts lowered minimum required contributions, decreasing the cost of constraining contributions to the pension during the Great Recession.

3.3.3 Macroeconomic conditions

Two macroeconomic factors can also influence this relative cost. First, fluctuations in the value of pension assets can change the regulatory cost of contributing less, since that cost

depends directly on the pension shortfall. When defined benefit firms faced rising asset prices as they did from 2003-2007, they also faced low costs of contributing less to their pension accounts because gains in market value improved plans' funding status. Rising asset prices may have prevented some firms from borrowing externally to make pension contributions. Second, changes in aggregate investment risk can influence agency costs of borrowing. When firms face a widespread credit crunch like the one associated with the Great Recession, bond spreads rise, reflecting higher agency costs of leverage in a credit crunch. Like rising asset prices, rising aggregate investment risk leading to tighter credit may also encourage some firms from borrowing externally to make pension contributions.

These dynamics likely contributed to pension firms' borrowing, investment and contribution decisions throughout the 2000s. Firms with high costs to contributing less to their pensions relative to their peers – “costly” pensions – would have supported higher external leverage ratios and made riskier investments from 2000-2007. The asset price declines from 2007 to 2009 meant that more firms faced costly pensions, as well as the decision to increase pension contributions to manage their new pension deficits. With high pension deficits and looming bankruptcy risk, external debt would be the preferred method to finance such pension contributions. However, drastic increases in perceived aggregate investment risk led to a credit crunch during the Great Recession. As a result, the cost of supporting high external leverage increased, especially for firms with high pension debt that were more prone to make risky investments. Therefore, firms with costly pensions during the Great Recession were less likely to support inflated leverage ratios – and, as a result, inflated investment risk – during the prime years of the credit crunch.

3.4 The Empirical Specification

This analysis implies a key empirical prediction: firms facing costly pensions will borrow more and make riskier investments than firms with less costly pensions when credit is cheap, but that difference will narrow when credit is more expensive. The rest of this paper explores this prediction over the period 2000 through 2013.

3.4.1 Specification

Consider, first, the borrowing decision of a firm that does not have a pension. Standard regressions investigating the determinants of corporate leverage include observable proxies for the tax benefits of debt, agency costs due to conflicts of interest, and bankruptcy costs (Rajan and Zingales 1995; Frank and Goyal, 2008):

$$\frac{\text{External Debt}}{\text{Non-Pension Assets}_{it}} = \Theta_1 \mathbf{F}_{it} + \mu_{it} \quad (3.1)$$

The outcome variable in equation 3.1 is the book leverage ratio of firm i in year t , \mathbf{F}_{it} is a vector of firm characteristics determining the optimal leverage ratio, and μ_{it} is unobserved characteristics that influence firms' borrowing decisions. These unobserved characteristics include error due to mis-measured proxies for the determinants of leverage.

Now, suppose the firm sponsors a defined benefit pension. Define pension debt as unfunded pension liabilities: total pension liabilities less pension assets. If external and pension debt are perfect substitutes:

$$\frac{\text{External Debt}}{\text{Non-Pension Assets}_{it}} + \frac{\text{Pension Debt}}{\text{Non-Pension Assets}_{it}} = \Theta_1 \mathbf{F}_{it} + \mu'_{it}$$

The regression framework analogous to equation 3.1 describes the ratio of external debt to non-pension assets as a function of its components:

$$\frac{\text{External Debt}}{\text{Non-Pension Assets}_{it}} = \Theta'_1 \mathbf{F}_{it} + \theta_2 \frac{\text{Pension Debt}}{\text{Non-Pension Assets}_{it}} + \mu'_{it} \quad (3.2)$$

If external and pension leverage are perfect substitutes and \mathbf{F}_{it} captures the observable determinants of debt without measurement error, $\Theta'_1 = \Theta_1$ and $\theta_2 = -1$: the determinants of debt, \mathbf{F}_{it} , should have the same impact on external leverage of firms without pensions as they do on the total leverage of firms with pensions, and an increase in pension leverage should be associated with an equivalent decrease in external leverage. Further, $\mu_{it} = \mu'_{it}$: the error term after incorporating pension debt includes the same unobservable characteristics of the firm that influence the leverage ratio.

If sponsoring a pension changes the firm's incentives or behavior in ways that indirectly influence its optimal external debt ratio, then Θ'_1 and μ'_{it} capture a behavioral response to pension obligations that Θ_1 and μ_{it} do not. In the theory proposed above, pension obligations make external debt more attractive and firms choose how much to borrow by trading off the costs of lowering contributions with agency costs of borrowing more to make contributions. The resulting behavioral response to pension obligations, $f(C_{it}, A_{it})$, depends on the firm's regulatory cost of contributing less to the pension (C_{it}) relative to the agency costs associated with borrowing more (A_{it}):

$$\frac{\text{External Debt}}{\text{Total Assets}_{it}} = \Theta''_1 \mathbf{F}_{it} + \theta_2 \frac{\text{Pension Debt}}{\text{Non-Pension Assets}_{it}} + f(C_{it}, A_{it}) + \mu''_{it} \quad (3.3)$$

When $f(C_{it}, A_{it})$ precisely captures this behavioral response to pension obligations and is

independent from the unobserved characteristics influencing the borrowing decision of a non-pension firm, $\mu_{it} = \mu''_{it}$. The behavioral response, however, will likely be correlated with unobserved factors influencing the firm's borrowing decision, and proxies for the behavioral response are subject to their own measurement error.

Several characteristics of the firm, regulatory environment, and macroeconomic environment influence the regulatory cost of contributing less (C_{it}) or agency cost of borrowing more (A_{it}). The level of pension debt and funding ratio interact with pension regulations to determine insurance premiums and required minimum contributions, while the magnitude of pension liabilities captures firms' exposure to market fluctuations through the pension account which, in turn, influence future premiums and required payments.

$$C_{it} = C \left(\frac{\text{Pension Debt}}{\text{Non-Pension Assets}_{it}}, \text{Pension Liabilities}_{it}, \text{Funding Ratio}_{it}, \text{Regulatory Characteristics}_{it} \right) \quad (3.4)$$

The firm pays the agency cost to borrowing more through its premium on external debt. This premium increases with external and pension leverage, as well as the amount of non-contractible investment risk the firm faces. Non-contractible investment risk can be idiosyncratic or aggregate.

$$A_{it} = A \left(\frac{\text{External}}{\text{Non-Pension Assets}_{it}}, \frac{\text{Pension Debt}}{\text{Non-Pension Assets}_{it}}, \text{Idiosyncratic Investment Risk}_{it}, \text{Aggregate Investment Risk}_t \right) \quad (3.5)$$

Each of the determinants of the relative cost described in equations 3.4 and 3.5 changed dramatically in the Great Recession. The specification studied in Section 3.6 controls for changes in pension leverage, pension liabilities, funding ratios, and year and industry (j) specific leverage patterns. The coefficients of interest in that section are on indicator variables that identify firms with particularly high regulatory costs to contributing less or particularly high aggregate investment risk. In the following specification, $MRC_{it} = 1$ when the firm faces an extremely high cost to lowering pension contributions and $\text{Credit Crunch}_{it} = 1$ in years in which the cost of external borrowing is particularly high for all firms. This leads to the following specification:

$$\frac{\text{External Debt}}{\text{Total Assets}}_{it} = \Theta_1 \mathbf{F}_{it} + \Theta_2 \mathbf{P}_{it} + \alpha \text{MRC}_{i,t} + \beta (\text{MRC}_{i,t} \times \text{Credit Crunch}_{i,t}) + \delta_j + \delta_t \quad (3.6)$$

where \mathbf{P}_{it} includes pension leverage, the magnitude of pension liabilities, and the pension funding ratio. These pension characteristics control for continuous changes in the cost of contributing less relative to borrowing more, as well as substitution between pension and external debt. Firms with particularly high cost pensions are expected to borrow more to make contributions ($\alpha > 0$), but be less prone to do this when the cost of credit is extremely high ($\beta < 0$). While this specification has been built considering leverage is the outcome variable, these predictions maintain when investment risk is the outcome variable, provided that \mathbf{F}_{it} and \mathbf{P}_{it} include external leverage and other determinants that directly influence the measure of investment risk.

3.4.2 Variable Definition

The outcome variables of interest in the following sections are measures of external leverage and investment risk. This section describes external leverage in reference to pension leverage, and investment risk as the firm's default premium measured from long-term bond ratings. The explanatory variables of interest are binary variables that indicate extremely high costs to contributing less and widespread high agency costs of external borrowing.

3.4.2.1 External leverage and pension leverage

Two measures of leverage are relevant to the analysis below: external leverage and pension leverage. External leverage is measured as the book ratio of long-term debt to total non-pension assets. Non-pension assets are the book value of total firm assets cleansed of adjustments that reflect pension income and expenses. Pension leverage is the ratio of unfunded pension liabilities – total pension liabilities, measured as the projected benefit obligation, less pension assets – to non-pension assets. Both pension liabilities and pension assets are reported off the balance sheet. The advantage of these measures is that they cleanly separate external from pension debt. Further, they define the relevant portion of pension debt to be those obligations that are not supported by the collateral of pension assets.

A standard measure of long-term leverage is the ratio of the book value of total liabilities to the book value of total assets, calculated from firms' 10-k reports and referred to as

balance-sheet leverage below. The book values of total assets and liabilities reflect adjustments for pension income and expenses reported in the cash-flow statement, and total liabilities includes unfunded pension obligations. Shivdasani and Stefanescu (2012) suggest, instead, a measure of consolidated leverage that incorporates off-balance sheet pension debt directly: the ratio of long-term debt and total pension liabilities to non-pension and pension book assets. They calculate this measure by cleansing book assets of adjustments associated with pension income and expenses, consolidating pension assets with non-pension assets, and consolidating total pension liabilities with long-term debt. Shivdasani and Stefanescu (2012) argue that a benefit of this consolidated leverage measure is to incorporate risk associated with high levels of pension obligations: a percentage decline in the market value of pension assets or interest rates will lead to higher future pension debt for firms with larger magnitudes of pension liabilities. While the measure of pension leverage used in this paper does not directly capture this component of pension risk, specification 3.6 controls for the magnitude of pension liabilities.

3.4.2.2 Investment risk

Differences in investment risk are measured by differences in default premiums implied by S&P long-term debt ratings. The methodology used to calculate S & P long-term debt ratings is designed to capture the probability that debt holders will receive their promised payments. This probability is a key factor in determining the bond spreads external lenders offer and, in turn, agency cost the firm faces. Differences in S&P ratings are then translated into differences in default premia using annual average bond spreads by rating notch for industrial firms, provided by Rueters.

While credit ratings have traditionally been a valuable measure of default risk, concern arose during the recession that the methodology used to rate bonds was a questionable indicator of their default risk during the mid-2000s. Increased attention to that methodology led to some substantial changes following 2008. Two factors ease potential concern that changes to ratings methodologies in the late 2000s bias the results below. First, questionable ratings practices related primarily to mortgage securities and banks. Financial institutions are excluded from the following analysis. Second, the specifications below include year fixed effects. The difference of interest in credit ratings is that between firms facing costly and less-costly pensions within year. For changes in ratings methodology to bias this result, those changes would have to be differentially applied to firms with costly and less-costly pensions.

3.4.2.3 Cost of contributing less to pension

In the analysis below, firms face high costs to lowering their pension contribution further when they contribute at or below the minimum required contribution. In equation 3.6, $MRC_{it} = 1$ when the firm contributes at or below the minimum required contribution and $MRC_{it} = 0$ when the firm contributes nothing or above the minimum required contribution. Firms contributing only the legally required minimum have two characteristics that identify firms with high costs to lowering pension contributions. First, they face substantial pension deficits that encourage them to finance with debt rather than equity. Second, they would face high regulatory penalties if they lowered contributions further. Minimum required contributions are positive when the pension faces a deficit and, as their name suggests, legally required. Consequently, any firm contributing at the minimum faces a pension deficit that encourages it to lean toward debt finance and a very high cost of contributing below their current level since it is legally prohibited. Rather than constrain pension contributions further, firms at the minimum ($MRC_{it} = 1$) likely borrow at higher premiums to avoid large regulatory penalties.

3.4.2.4 Agency cost to external borrowing

Agency costs to external borrowing are high, $Credit\ Crunch_{it} = 1$ in specification 3.6, during the years of the aggregate credit crunch associated with the Great Recession: 2009, 2010, and 2011. The collapse of Lehman Brothers in September of 2008 instigated a period of unprecedented financial uncertainty. Traditional measures of the lending environment describe aggregate uncertainty that remained high throughout 2011 and coincided with low willingness to lend that increased corporate borrowing costs across the board.² $Credit\ Crunch_{it}$, then, captures high borrowing costs due to high aggregate investment risk facing all firms. Many firms also face idiosyncratic factors that raise the particular borrowing rate they face. In fact, firms contributing at the minimum required contribution – identified as having high costs to contributing less – are more likely to face high idiosyncratic risk: high idiosyncratic risk leads to high agency costs of borrowing relative to regulatory costs of lowering pension contributions and encourages firms to decrease pension contributions to the lowest possible. Those idiosyncratic agency costs are not high enough, however, to prevent the firm from borrowing more to avoid marginal pension penalties. The aggregate credit crunch in 2008-2011, on the other hand, may have driven agency costs of borrowing high enough to discourage some firms from borrowing enough to contribute above the minimum and encourage others to use funds they would have spent on other

²<https://www.federalreserve.gov/boarddocs/snloansurvey/>

investments, rather than borrow, to meet the minimum required contribution.

3.4.3 Identifying Variation

The ideal experiment to test this prediction identifies exogenous variation in the cost of contributing less to the pension account relative to the agency cost associated with borrowing more externally. This paper looks at average differences in borrowing and investment risk among firms contributing at the minimum required contribution and those contributing above. Non-linearities in the minimum required contribution as a function of the pension funding ratio introduce exogeneity in the cost firms face to lowering pension contributions nearer to the minimum, and firms contributing at or below the minimum identify themselves to have the highest costs of lowering contributions. The regressions in the following section control for the pension funding status to isolate some of this regulatory variation in the cost of constraining contributions relative to issuing more external debt.³

Previous work has similarly considered variation in pension contributions due to legal differences in the minimum required contribution, but as an instrument for cash flow rather than to directly measure the regulatory cost of contributing less to the pension. This literature has used two approaches to capture legal differences in the minimum required contribution. The first approach is to use policy changes that decrease the minimum required contribution for all firms (Dhambra, 2014; Kubick et. Al, 2014). The history described above suggests that pension regulations change in response to macroeconomic conditions and investment risk facing firms. As a result changes in pension legislation are unlikely to induce exogenous variation in minimum pension contributions. The second approach has been to use non-linearities in the formula used to calculate minimum required contributions as a function of the plan funding ratio. Bakke and Whited (2012) use a regression discontinuity design that recognizes the funding ratio as the running variable, while Rauh (2006) exploits these non-linearities with an instrumental variables specification that controls for the funding ratio. Frequent sorting above funding thresholds throughout the 2000s, which may not have been present in the period Bakke and Whited studied (1990-1998), prevents the use of a regression discontinuity design in this paper. Instead, this paper builds on the method used in Rauh (2006), but recognizes that exogenous differences in minimum required contributions influence not only cash flow, but also firms' borrowing and investment decisions.

³See Rauh (2006) or Bakke and Whited (2012) for a detailed description of how the minimum required contribution changes as a function of the firm's funding ratio.

3.5 Data and Sample Selection

Two sources of data provide information on publicly listed firms that sponsor defined benefit pensions. Compustat, data compiled from firms' financial statements, describes the general financial status of the firm, including long-term borrowing and S&P rating, and reports whether the firm sponsors a defined benefit pension. The Form 5500, regulatory data released by the Department of Labor, provides detailed plan-level information on all pension plans, including an indicator of whether the firm makes only the minimum required contribution. This section describes the sample and potential selection that results from merging the two datasets to explore the key prediction: defined benefit firms contributing at the minimum required contribution should borrow more and make riskier investments prior to 2008, but these differences should narrow when financing tightens from 2009-2011.⁴

3.5.1 Sample Selection

The sample of publicly-listed firms available in Compustat is limited to all firms for which data are continuously available, beginning in 2000, that report pension assets on their balance sheet. The sample excludes financial and utilities firms (SIC codes 6000 through 6999 and 4900-4999), and those firms for which pension asset or debt information is missing. The final sample includes 3,806 firms that report a defined benefit pension for at least one year between 2000 and 2013. Table 3.1 describes the main characteristics of this sample in the last column. Defined benefit firm in Compustat support long-term debt equal to 26 percent, on average, of their total non-pension assets. Their average pension shortfall, measured as the difference between the firms' projected benefit obligation and their pension assets reported in the footnotes of their 10-ks, is 3 percent of total non-pension assets.

The Form 5500 data, including all plans with over 100 participants in each year, are filed by firms that are both publicly-listed and not publicly-listed; therefore, many of the firms that sponsor pension plans included in Form 5500 data will not be included in Compustat.

⁴The analysis in this section focuses on Compustat firms that are matched to pension plans in the Form 5500 using the employer identification number and a fuzzy match method on firm name. The match rate is approximately 11 percent for DB sponsors reported in the Form 5500 and 35 percent for firms that report a pension plan in Compustat. Many sponsors on the Form 5500 are not publicly-listed and therefore will not appear in Compustat. Between 1990 and 1998, cusips of plan sponsors appeared on the Form 5500 and, as a result, this alternative time period yields a higher match rate. However, an important regulatory change in 1990 make the following years a less useful environment to test these model predictions. Prior to 1990, many firms held large surpluses in their pension plans as a method of allowing assets to accumulate tax-free. In 1990, the excise tax increased from 20 to 50 percent (following an increase from 0 to 20 percent between 1986 and 1987). This excise tax effectively discouraged firms from maintaining pension surpluses; as a result, many firms were contributing nothing to their pension accounts throughout the 1990s to decrease existing pension surpluses.

Entities in the Form 5500, described in the first two columns of Table 3.1, are defined by their employer identification number, a finer level of consolidation than the Compustat identifier used to describe the number of firms in the last three columns. Columns 1 through 4 exclude Form 5500 plans sponsored by firms in the financial and utilities sectors and are isolated to the years 2000 through 2013. This table reports separately plan-years in which the firm contributes nothing or above the minimum required contribution, and those in which the firm contributes at the minimum required contribution or below. The full sample amounts to 12,540 plans to which sponsors have contributed zero or above the minimum required contribution at least once from 2000 through 2013, and 4,725 plans to which sponsors have contributed at or below the minimum required contribution at least once over that time frame. Plans to which the firm contributes at the minimum tend to be smaller with lower funding ratios. Unsurprisingly, those plans receive lower total contributions and face higher minimum required contributions. They also maintain an average pension deficit of \$2.2 million, in comparison to the average pension surplus of \$43.2 million among plans to which the firm contributes nothing or above the minimum required.

The final matched sample, described in columns 3 and 4, includes observations from 1,047 different firms that contribute above the minimum required contribution at some point between 2000 and 2013, and 474 firms that contribute at or below the minimum required contribution at some point over that period. Firms in the matched sample support slightly higher long-term leverage and pension leverage than the full Compustat sample: firms contributing above the minimum maintain average long-term leverage of .28 and median pension leverage of .02, in comparison to average long-term leverage of .26 and median pension leverage of .01 among the full Compustat sample. Matched firms are also larger and less profitable, with average log sales over 7 and an average ratio of cash to non-pension assets of .08, than the full Compustat sample that supports average log sales of 6.88 and ratio of cash to non-pension assets of .13. While the market-to-book ratio is similar at the median, it is substantially smaller than the full sample at the mean; this implies that pension firms with very high book-to-market ratios – which is often considered a proxy for growth opportunities – are not included in the final analysis sample.

The comparison of columns (1) and (2) versus (3) and (4) sheds light on how well the final sample represents all private employer-sponsored pension plans with over 100 participants. Like all plans with over 100 participants, plans in the matched sample (columns 3 and 4) show lower funding ratios, and pension deficits rather than surpluses, among firms contributing at the minimum relative to firms contributing above the minimum. Plans in the final sample, however, are larger in terms of contributions, pension obligations, and participants. Further, unlike the full Form 5500 sample, plans receiving the minimum con-

tribution are larger, both in terms of total participants and in terms of total obligations, than their counterparts receiving above the minimum required contribution. This suggests that many small, under-funded plans to which firms contribute only the minimum required contribution are excluded from the final analysis sample.

The final sample, therefore, captures slightly larger firms with significantly larger pension plans. These are the firms among which the predicted pattern – pro-cyclical borrowing and investment risk – should be strongest. The under-funded plans that are smaller relative to firm size, excluded from this sample, should impose a cost of contributing less than is minimal in comparison to agency costs associated with borrowing more. As a result, the model predicts that these firms contribute at the minimum required contribution. However, the small size of the pension plan relative to total assets would allow the firm to make minimum required contributions with only slightly higher leverage, implying a smaller impact of this “costly pension” on the firm’s total leverage ratio and investment risk would be minimal. Therefore, the final sample that excludes these firms should display larger differences in borrowing and investment risk between firms with high and low cost pensions.

3.5.2 Sample Description

Table 3.2 compares firms in the matched sample that contributed at or below the minimum required contribution to at least one plan to firms that contribute zero or above the minimum to all plans in 2001, 2007, and 2010. The two outcome variables of interest are the ratio of long-term debt to non-pension assets, or external leverage, and the S&P long-term bond rating. The external leverage ratio falls from 2001 to 2010 among both groups of firms. However, it is lower throughout the period among firms that contribute above the minimum required contribution. The long-term bond rating is converted to an index that ranges from 0 to 1. The highest rating, AAA, registers as 1 on this index, while the lowest rating, D, registers as 0. Each notch increase in ratings is equivalent to an increase in the index of $.04\bar{5}$. A rating of $.6$ is equivalent to a S&P long-term bond rating of BBB-. Firms contributing above the minimum face lower ratings than their counterparts contributing at or below the minimum. The median ratings index remains near $.6$ for firms contributing above the minimum required contribution throughout this period. Among firms contributing at the minimum required contribution, however, the median falls from $.48$ to $.45$ from 2001 to 2007, and rises to $.57$ by 2010.

The funding ratio, pension shortfall, and pension obligations describe a generally rising pension burden over this period. The funding ratio, reported on the Form 5500, is the ratio of pension assets to pension liabilities of the firm’s largest pension plan. Most pensions

receiving contributions of zero or above the minimum required began the decade funded or over-funded, with a median funding ratio of 99 percent. This median funding ratio fell to 83 percent by 2010. Pensions receiving the minimum required contribution, on the other hand, faced a median funding ratio of 86 percent in 2001. This funding ratio fell slightly over the decade, but was very similar to funding ratios among plans with higher contributions in 2010. The ratio of unfunded pension liabilities to total assets (labeled pension shortfall) shows a similar pattern. The absolute magnitude of pension obligations, however, describes an important difference between costly plans receiving the minimum required contribution or below, and less costly plans receiving contributions of zero or above the minimum from 2001 through 2010: prior to 2010, costly pension plans tended to be smaller in terms of total obligations; in 2010 costly plans were substantially larger.

Several firm characteristics mirror this pattern. First, the percent of firms with less costly pensions that contributed nothing to their largest pension fell from above 50 in 2001 and 2007, to 20 in 2010. This suggests that many firms that began contributing at the minimum during the credit crunch were previously contributing very little or nothing to well-funded pension accounts. Second, the firms with costly pensions contributing at the minimum were smaller, younger and faced a lower chance of bankruptcy (according to their Z-score, a measure that increases with firms' chance of bankruptcy) than their counterparts with less costly pensions in 2001 and 2007. However, these characteristics reversed in 2010: firms with costly pensions during the credit crunch were larger, older, and faced higher bankruptcy risk than their counterparts with less costly pensions. Firm's tangibility and profitability were similar across these two groups throughout the 2000s. The following analysis controls for this structural difference in firms contributing at the minimum before and during the credit crunch using detailed controls for leverage and investment decisions within industry and, in a separate specification, within firm. Further, non-linearities in minimum required contributions as a function of pension funding status introduce exogenous variation in firms' cost of reducing pension contributions when they already contribute at the minimum.

3.6 External leverage and investment risk among firms with costly pensions

Figure 3.2 shows the fraction of firms that contribute at or below the minimum required contribution to at least one plan from 2000 through 2013.⁵ Prior to the credit crunch of

⁵In 2008, the DOL changed reporting forms for actuarial data, from the Schedule B to the Schedule SB. The first year of new reporting forms, 2008, is not released electronically. As a result, the year 2008 is omitted

2009, approximately 10 percent of firms contributed at the minimum required contribution to at least one plan; 55 percent of those firms were contributing at or below the minimum to all plans. The fraction of firms contributing at or below the minimum to at least one plan was significantly higher during the Great Recession than earlier in the decade, peaking at 25 percent in 2011, with 57 percent of those firms contributing at or below the minimum to all plans. The previous section suggests that the new firms contributing at the minimum during the credit crunch were larger and older and, while their pension deficit was similar relative to total assets, the absolute magnitude of their pension obligations was larger than firms contributing at the minimum earlier in the decade.⁶ Further, firms that did not contribute at or below the minimum during the credit crunch were substantially less likely to contribute nothing than they were before the credit crunch (see appendix D). These patterns suggest that some firms allowed large, well-funded plans to accumulate without contributing through the early 2000s, but were required to make contributions to those plans when the value of pension assets fell in the Great Recession.⁷

Figure 3.3 compares the mean ratio of debt to non-pension assets and the ratings index of firms that contributed the minimum required contribution to those of firms that contributed above the minimum. As the model predicts, debt levels are higher and bond ratings lower among firms that contribute at the minimum required contribution in 2007 and earlier. The differences between the groups narrow during the years of the credit crunch, 2009 through 2011.

This pattern is a combination of two effects. The first is that firms contributing at the minimum before the credit crunch face higher borrowing costs during the credit crunch that discourage them from increasing leverage to make minimum contributions. Figure 3.4 isolates the sample of firms that contributed at the minimum required contribution at some point before the recession, and shows that many of them continued to do so during the recession. Figure 3.5 shows that external leverage ratios among these firms were higher from 2000 through 2005, and ratings lower, than firms that contributed at the minimum prior to the credit crunch but not during. Figure 3.6 returns to the full sample of firms to show within-firm differences in external leverage and ratings in years when firms contribute at and above the minimum. Within firm differences appropriately identify changes in the behavioral response to contributing at the minimum before and during the credit crunch

from the following analysis.

⁶There is substantial overlap in firms that contribute at the minimum before and after the recession: 335 firms contribute at the minimum for at least one year from 2000 through 2007, with 244 of those firms contributing for 2 years or fewer; while 279 firms contribute at the minimum for at least one year from 2009 through 2011, with 171 of those firms contributing at the minimum only once over that period; and 90 firms contribute at the minimum for at least one year in both of those time frames.

⁷See Appendix D for detail on firms contributing at zero throughout the 2000s.

if consistent firm characteristics determine which firms contribute at the minimum only during the recession. From 2000 through 2007, firms support debt ratios that are higher relative to their average debt ratios, and ratings that are lower relative to their average rating, in years in which they contribute at the minimum than in years when they contribute above the minimum. Again, this difference narrows from 2009 through 2011.

The second effect contributing to the narrowing of the gap between external leverage and ratings is that more firms face large pension deficits following the asset price declines of 2008-2009 and choose to contribute at the minimum. These firms may have contributed above the minimum absent market declines but, instead, borrow from pensioners by constraining pension contributions to support investment during the credit crunch. These firms may support lower debt ratios and higher ratings than firms that contributed at the minimum earlier in the decade. Figure 3.7 isolates the sample of firms that contribute at the minimum at some point between 2009 and 2011 and shows the fraction of those firms contributing at the minimum in each year. Unlike those firms contributing at the minimum before the credit crunch that continued to do so after 2008, firms contributing at the minimum during the credit crunch were substantially less likely to do so before 2008. Figure 3.8 shows that the pro-cyclical pattern of debt and investment risk among firms contributing at the minimum maintains in this constrained sample of firms. The fluctuations among firms at the minimum are likely magnified in this figure because firms contributing the minimum both before and during the credit crunch identify the borrowing and ratings averages for firms at the minimum before 2008; these firms, with continually high costs to contributing less relative to agency costs of borrowing more, will support the highest leverage ratios when credit is loose.

3.6.1 Empirical Specification

These patterns are consistent with the hypothesis that firms facing a high cost of contributing less borrow more, face higher agency costs, and make riskier investment decisions in years with easy financing, but constrain their borrowing and make fewer risky investments in years with tighter financial markets. The following regression, slightly modified from specification 3.6, explores this hypothesis further:

$$y_{it} = \alpha \text{MRC}_{i,t} + \beta (\text{MRC}_{i,t} \times \text{CreditCrunch}_{i,t}) + \Theta_1 \mathbf{P}_{it} + \Theta_2 \mathbf{F}_{it} + \delta_{j \text{ or } i} + \gamma_t \quad (3.7)$$

In specification 3.7, y_{it} is either the ratio of long-term debt to non-pension assets or the index created from the S&P rating, i indexes the firm, j indexes the industry, t indexes the year, $\text{MRC}_{i,t}$ is an indicator of a firm that contributes at the minimum required contribution

to at least one pension plan, and $\text{Credit Crunch}_{i,t}$ is an indicator for whether the economy faces a credit crunch in year t that proxies for widespread credit constraints between 2009 and 2011. Tables 3.3 and 3.4 include industry fixed-effects to compare debt and ratings of firms with costly and less costly pensions within industry (δ_j), while Table 5 includes firm fixed-effects to compare debt and ratings within firm (δ_i).

The vector of controls for the firm's pension liabilities, \mathbf{P}_{it} , includes the ratio of unfunded liabilities to total non-pension assets; the log of the magnitude of the firm's projected pension obligations; and the funding status of the largest account that receives the minimum required contribution, for firms contributing at the minimum, or the largest pension account overall for firms contributing above the minimum. The coefficient α is intended to capture variation in the cost of contributing less relative agency risk of borrowing more – not the actual cost of sponsoring a defined benefit pension. The first two measures of pension liabilities proxy for the cost of maintaining a pension account, as maintenance costs rise with each. Further, the formula used for calculating the minimum required contribution is a non-linear function of the pension funding status.⁸ By controlling for this funding status, the regression isolates in α the variation in the minimum required contribution that is exogenous from the funding status of the pension.

The vector of controls for the firm's financial position, \mathbf{F}_{it} , differs with the outcome variable. When the outcome variable is long-term leverage, controls include those identified by Frank and Goyal (2008) to reliably predict book leverage ratios: tangibility of assets, profitability, and median leverage within industry. Following the literature, the specification also includes the market-to-book ratio, firm size measured by log sales, firm age, and Altman's Z-score (Rajan and Zingales, 1995; Frank and Goyal, 2008; Shivdasani and Stefanescu, 2012). When the outcome variable is the firm's credit rating, additional controls include the log of non-pension assets, the ratio of debt to total assets, and the interest coverage ratio. With these controls, the specification captures variation in firms' financial status that can predict differences in their long-term leverage ratio or credit rating.

The coefficients of interest are α and β . When firms face high costs to contributing less to their pension, proxied by MRC_{it} , they should borrow more and make riskier investment decisions when financing is cheaper: $\alpha > 0$ when $y_{i,t}$ is the ratio of debt to non-pension assets, and $\alpha < 0$ when $y_{i,t}$ is the continuous ratings index. When financing is tighter, firms facing high costs to contributing less face higher costs of borrowing more relative to constraining their pension contributions. As a result, they constrain external borrowing, face smaller increases in agency cost, and maintain lower investment risk. This suggests

⁸See Rauh (2006) and Bakke and Whited (2012) for detailed explanation of the formula used to calculate these minimum required contributions and this identification strategy.

that the total effect of contributing at the minimum required contribution during a credit crunch, $\alpha + \beta$, should be weaker than during a time of easy financing: $|\alpha + \beta| < |\alpha|$.

3.6.1.1 Debt to non-pension assets

Table 3.3 presents estimates of α and β when the dependent variable is the ratio of debt to non-pension assets, controlling for industry fixed-effects. This table shows specifications that jointly consider firms contributing at the minimum required contribution in all years (odd-numbered specifications), and specifications that separately consider firms contributing at the minimum required contribution during normal times and during a credit crunch (even-numbered specifications). In the preferred complete specification (6), $\alpha = .0459$ implies that pension firms that contribute at the minimum required contribution support a leverage ratio that is 4.6 percentage points higher than the leverage ratio of their counterparts that face less costly pensions relative to agency cost. This difference, however, disappears in years in which credit constraints are widespread: $\beta = -.0549$ suggests that firms facing contribution constraints and credit constraints do not borrow significantly more than their counterparts that do not face contribution constraints. Under the fixed-effects specification in Table 3.5, firms support leverage ratios that are 2.14 percentage points higher in years when they contribute at the minimum than in years in which they contribute above the minimum when the economy does not face a credit crunch. This difference, again, disappears in years in which credit constraints are widespread: $\beta = -.0354$ suggests that firms do not borrow significantly more in years in which they are contributing at the minimum than in years in which they are contributing above the minimum from 2009 through 2011. Defined-benefit sponsors raise more debt, relative to their industry average, in years in which financing is easy and they contribute at the minimum required contribution than in years in which they make unconstrained contributions. Yet when facing financing constraints, firms facing higher costs to lowering their pension contributions do not take on higher leverage: they likely use other sources of funds to finance their pension contributions.

The four groups of specifications presented in Table 3.3 explore several possible determinants of pension firms' leverage ratios. Models (1) and (2) consider uncontrolled average debt ratios: firms with high costs to lowering pension contributions support leverage ratios that are 3.7 percentage points higher than their counterparts with lower pension costs; these ratios are 5.8 percentage points higher during periods of easy credit, but no different during the credit crunch. Specifications (3) and (4) consider the role of pension leverage. In theory, pension and external leverage could be complements or substitutes.⁹ Specifications

⁹See Shivdasani and Stefanescu (2012) for an explanation of how the tax benefits of debt may create a

(3) and (4) control for the level of pension debt the firm maintains and find higher external debt ratios among firms contributing at the minimum. This suggests that pension and external debt may function as substitutes rather than complements. Controlling for the plan funding status allows regulatory variation in non-linear minimum required contributions to help identify α and β . A variety of financial factors may very well be correlated with firms' decisions to contribute only the minimum to their pensions. Specifications (5) and (6) control for the impact of a range of financial characteristics that are typically considered determinants of debt. Controlling for these factors minimally reduces the estimated difference in leverage between firms at and above the minimum required contribution: during times of easy credit, firms contributing at the minimum support leverage ratios that are only 4.6 percentage points, rather than 6.1 percentage points, higher than their counterparts contributing above the minimum.¹⁰ The more conservative estimates in Table 3.5 that control for firm, rather than industry, fixed-effects present a similar pattern: firms support leverage ratios that are 2.1 percentage points higher in years in which they contribute at the minimum than in years they contribute above the minimum from 2000 through 2007 and 2012-2013, but this difference is insignificant during the credit crunch.

Finally, specifications (7) and (8) explore a situation in which high costs of contributing less to the pension may play a less important role in the firm's borrowing decision. Firms' decisions to borrow more to make minimum required contributions result from contracting problems and conflicts of interest between stockholders and bondholders. The decisions of a firm with negative owner equity, however, may be less driven by this conflict. Specifications (7) and (8) control for an indicator of whether the firm faces negative owner equity. As predicted, absent the differences driven by variations in the conflict of interest, firms with costly pensions support a leverage ratio that is only 2.5 percentage points higher than their counterparts with less costly pensions when facing easy credit.

3.6.1.2 S&P Long-term bond ratings

Table 3.4 presents estimates of α and β when the dependent variable is the ratings index. Lower ratings suggest higher default probabilities. Like Table 3.3, this table shows specifications that jointly consider firms contributing at the minimum in all years (odd-numbered specifications) and specifications that separately consider firms contributing at the minimum during normal times and in the credit crunch (even-numbered specifications). The

substitutes relationship between pension and external debt and careful empirical evidence of such a pattern, or Lay (2016) for an overview of several theories of the relationship between pension and external debt.

¹⁰Robustness checks in appendix 2 show that adding controls sequentially maintains a steady estimate of α .046.

preferred specification (6) estimates $\alpha = -.0376$ and $\beta = .0338$. These estimates suggest that firms contributing the minimum required contribution in years of easy credit face bond ratings that are over three-quarters of a notch lower than their counterparts contributing above the minimum. At the average sample rating of BBB- for firms contributing at the minimum, a decrease in the S&P rating by three-quarters of a notch is equivalent to an increase in the 3-year bond spread over treasuries of 24 basis points, or an increase in the 3-year default premium of 22 percent.¹¹

The four groups of specifications in Table 3.4 shed light on the role of several determinants of firms' bond ratings. Models (1) and (2) show that the uncontrolled average difference in ratings is $\alpha = -.043$, or about one ratings notch, from 2000 through 2013. This estimate is driven by lower ratings among firms contributing at the minimum from 2000 through 2007 and after 2012. In specification (2), $\alpha = -.0969$: firms contributing at the minimum face lower ratings by one and a half notches. The magnitude of this estimate diminishes substantially in specifications (3) through (8) after controlling for the plan funding status and other determinants of ratings. Estimates in Table 3.5 controlling for firm fixed effects suggest a similar pattern. In the preferred specification (7), firms contributing at the minimum required contribution face bond ratings that are $\frac{2}{5}$ notches lower, or a default premium that is 5.9 percent higher, than their counterparts with less costly pensions. Again, this difference disappears during the credit crunch.

3.7 Discussion

The previous section suggests that firms making the minimum required contribution borrow more than their counterparts contributing above the minimum during periods of easy financing (2000-2007, 2012-2013) than they do during a credit crunch (2009-2011). This financing pattern could motivate several different patterns of investment. Suppose, for example, that firms contributing at the minimum in 2000 through 2007 borrowed more so that they could make the minimum required contribution without decreasing their investment. In this situation, bond ratings among firms contributing at and above the minimum should be the same from 2000 through 2007 after controlling for standard determinants of ratings, including leverage ratios. Continuing with this example, suppose high borrowing costs prevent firms with costly pensions from borrowing more in 2009 through 2011. As a result, firms with high minimum required contributions are forced to cut back on profitable investments so that they have enough cash to contribute to their pensions. In this example, firms contributing at the minimum during the credit crunch forgo profitable investment

¹¹Using the differences in the bond spread for industrials by S&P rating in 2006 provided by Rueters.

opportunities and would have lower ratings than their counterparts contributing above the minimum. In specification 3.7, α would be zero and β negative when the outcome variable is the ratings index.

Section 3.6 describes a different pattern. Instead, α is negative, β is positive, and $\alpha + \beta = 0$: firms contributing at the minimum required face lower ratings than their counterparts contributing above the minimum required during times of easy credit, and no difference in ratings during the credit crunch. This suggests that firms that borrowed to make their minimum required contributions actually made worse investment decisions during normal times than their counterparts that had less costly pensions and lower borrowing. During the credit crunch, firms contributing at and above the minimum contribution borrowed the same amount and faced the same bond ratings.

One potential concern is that this finding of no difference between firms contributing at and above the minimum during the credit crunch is driven by a smaller difference between those two groups in the average realized regulatory cost of lowering contributions during the credit crunch than before it. This difference could be smaller during the credit crunch if firms contributing above the minimum prior to the recession contributed significantly above the minimum and faced an extremely low regulatory cost to lowering contributions, while firms contributing above the minimum during the credit crunch only contributed only slightly higher than the minimum and faced higher regulatory costs to lowering contributions. In this case, the difference in regulatory costs to lowering contributions between firms at and above the minimum would be smaller during the recession than before. As a result, the expected difference in leverage and investment risk between these groups would also be smaller. Two empirical facts run counter to this scenario. First, firms that contributed at the minimum required contribution during but not before the credit crunch, in fact, contributed closer to their minimum, on average, prior to the credit crunch than their counterparts that never contributed at the minimum. Using this metric, the difference in the regulatory cost of lowering contributions should be larger during than before the credit crunch. Second, Figure 3.3 shows that debt and ratings levels among firms at the minimum during the credit crunch the recession were in line with debt and ratings levels among firms above the minimum prior to the credit crunch. If the insignificant coefficients during the recession were driven by smaller differences in regulatory costs, then firms at the minimum would borrow less, on average, than they did before the recession, while firms above the minimum would borrow more.

A second potential concern is that the indicator of high regulatory costs employed in specification 3.7 is correlated with unobserved investment opportunities. Firms with high unobserved investment opportunities may have high demand for cash flow that is not cap-

tured by the standard controls and may also contribute only the minimum required to the pension. At the same time, unobserved investment opportunities can influence the outcome variables of interest. Asymmetric information between the borrower and lender would imply that unobserved investment opportunities create a wedge between the internal and external cost of funds, encouraging firms to finance more with inside equity than debt. Further, firms with unobserved investment opportunities would likely have higher than expected ratings. This dynamic implies that the estimate of the impact of high regulatory pension costs on the external leverage ratio would be biased downward, while the estimate of that impact on ratings would be biased upward. Consequently, it is despite this bias that, before the recession, leverage is higher and ratings lower for firms contributing at the minimum than their counterparts contributing above the minimum. Further, while this bias contributes to the narrowing of the gaps between firms contributing at and above the minimum during the credit crunch, it is because firms are constraining their contributions to their pensions so that they have funds to finance these unobserved investment opportunities: they are borrowing from their pensioners to support productive investment.

The theory presented in Section 3.3 turns to the impact of pension regulations on firms' financing and investment incentives when agency problems exist among stakeholders to explain the patterns revealed in this paper. Firms with large pension debts that can be written-off in bankruptcy at a lower cost than traditional bonds see debt as a more attractive form of finance than equity. Firms contributing at the legally required minimum are at a corner solution: they would like to contribute less, but are legally prohibited from doing so. These firms borrow externally to make their contributions. Contracting problems between stockholders and bondholders encourage these firms with inflated leverage to over-invest in risky projects. In a credit crunch, external debt is more expensive relative to the cost of contributing less to their pension. Firms finance pension contributions out of internal funds, diverting money from socially risky investments. This leads to a pattern of high debt and risky investments (low ratings) among firms contributing at the minimum required contribution during normal times, but more similar levels of debt and investment risk during a credit crunch.

3.8 Conclusion

Macroeconomic conditions rendered defined benefit pension plans particularly costly throughout the 2000s. Market declines in 2001-2002 led to large losses in the value of pension assets. At the same time, falls in interest rates implied higher discounted levels of pension liabilities. In 2003, the aggregate funding ratio of private pensions hit 84 percent, a

historical low, while the total amount of employer contributions increased five-fold from the beginning of the decade. Asset price increases throughout the mid-2000s and changes in pension regulations helped pension plans regain funding status and lowered contribution requirements. Yet, just after the aggregate funding ratio climbed above 100 percent in 2007, the Great Recession issued in a new decline in market values of pension assets and further increased the present discounted value of pension liabilities.

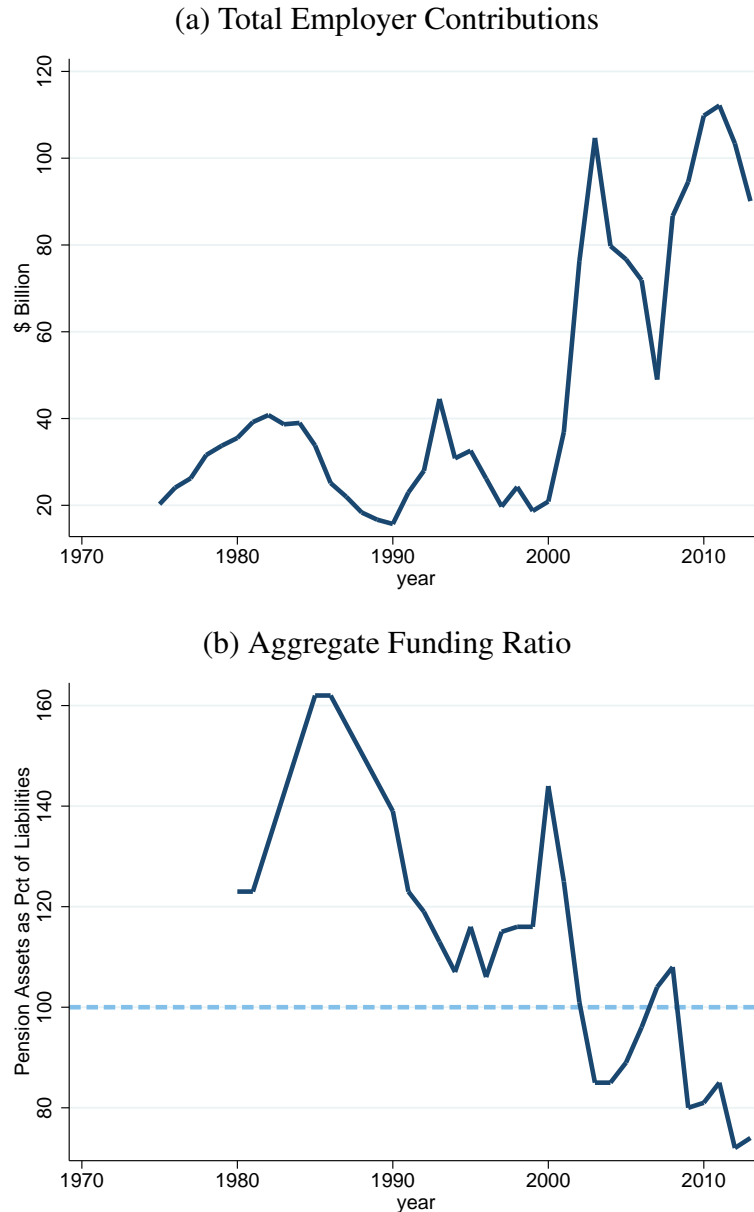
As a result of these dynamics, costly pensions with large deficits and high contribution requirements were a prominent concern in the 2008 financial crisis. The high profile bankruptcies of General Motors and Chrysler, two automakers deemed “too big to fail,” incited further concern regarding how these costly pensions influenced firms’ performance when the economy needed stimulus. A prevailing concern has been that large required pension contributions during the recession diverted cash-flow that is in high demand from productive investments. However, this concern ignores pension regulations that allowed firms to temporarily waive or reduce pension contributions, and the potential impact of interactions between pension regulations and existing stakeholder conflicts on how firms chose to invest.

This paper suggests that the real detrimental impact of costly pensions on firm performance occurred before the recession: when firms with costly pensions faced the easy financing of the mid-2000s, they borrowed externally to make pension contributions and supported leverage ratios that were 4.6 percentage points higher than their counterparts with less costly pensions. At the same time, conflicts of interest between their managers and pensioners encouraged managers to make investments that increased default premiums by 22 percent relative to their counterparts with less costly pensions. During the recession, firms with costly pensions did not increase leverage – because external financing was more costly than decreasing pension contributions – and their default premiums were no higher than their counterparts with less costly pensions. This dynamic suggests that, in the recession, firms with costly pensions borrowed from pensioners without borrowing externally to decrease the regulatory cost of pensions. They also did not have higher default premia than their counterparts with less costly pensions, suggesting that diversion in cash flow to pension contributions was minimal or from over-investment in risky projects, rather than productive investment.

A full treatment of how costly pensions influenced firm performance in the 2008 recession would take into account dynamics beyond firms’ adjustment in borrowing and investment risk in response to costly required pension contributions within year. This paper finds that costly pensions encouraged firms to borrow more and assume higher default premiums in the mid-2000s. Were those firms, in fact, more likely to default in the turmoil following

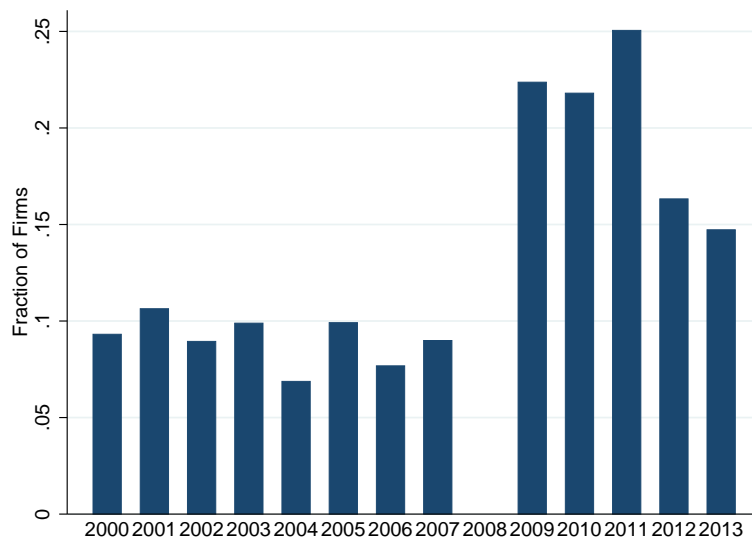
the collapse of Lehman Brothers? Raising another question: not all pension plans experienced the market crash of 2008 in the same way. Some firms in the sample studied in this paper lost as much as 55 percent of total pension assets from 2007 to 2009, while others gained as much as 32 percent. Did firms that experienced worse performance in their pension account similarly experience worse performance in their general accounts over the recession? These are some of the remaining questions about how defined benefit pensions influenced firm performance over the Great Recession.

Figure 3.1: Employer-Sponsored Defined Benefit Plans, 1975-2013



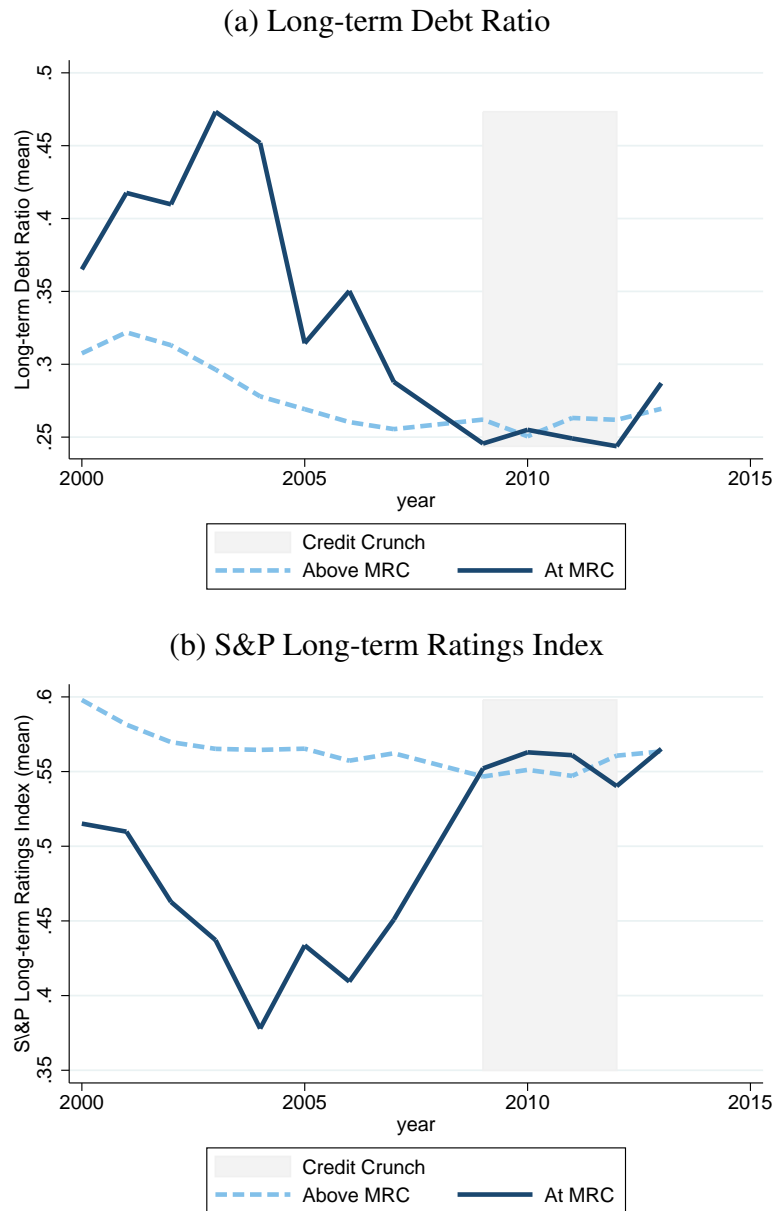
Notes. These figures show aggregate data for all single-employer defined benefit pension insured by the Pension Benefit Guarantee Corporation. Employer contributions represents all employer contributions made to insured plans within the year. The aggregate funding ratio is the ratio of total assets held in insured plans to the total projected benefit obligation of insured plans. Note that the funding ratio is available in 1980, 1985, and then every year from 1990 through 2013. Contributions are available at an annual frequency from 1975 through 2013. Data source is the 2014 Pension Insurance Data Book released by the PBGC (<http://www.pbgc.gov/prac/data-books.html>).

Figure 3.2: Firms Contributing at Minimum Required Contribution



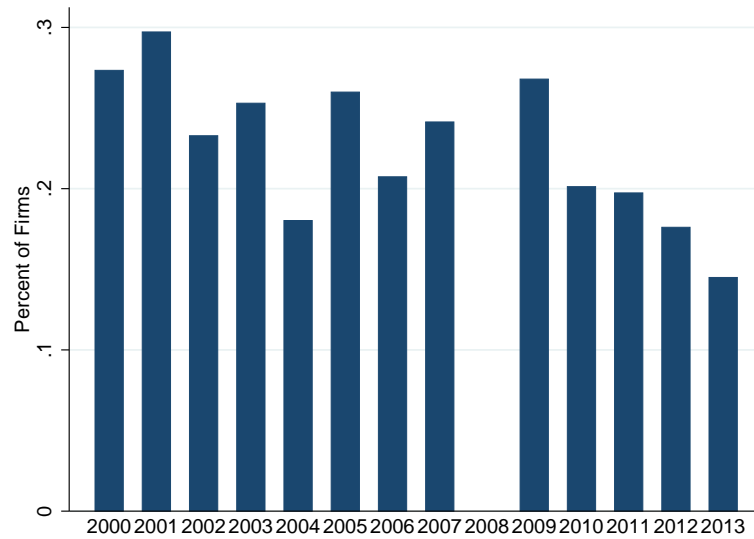
Notes. Shows the fraction of firms that contribute at or below the minimum required contribution to at least one pension plan reported on the Form 5500 and matched to its sponsor in Compustat. The base sample is the matched sample described in Table 1. Plans are categorized as contributing at or below the minimum required contribution if total employer contributions for the given year, reported in schedule B of the Form 5500, are less than or equal to the minimum required contribution reported on that same schedule. The Department of Labor shifted to electronic reporting in 2008; the first year of data following this shift, 2008, is not available in the Form 5500 data released online. The method by which firms report contributions and minimum required contributions remains the same before and after 2008.

Figure 3.3: Debt and Ratings of Firms Contributing at and above the Minimum



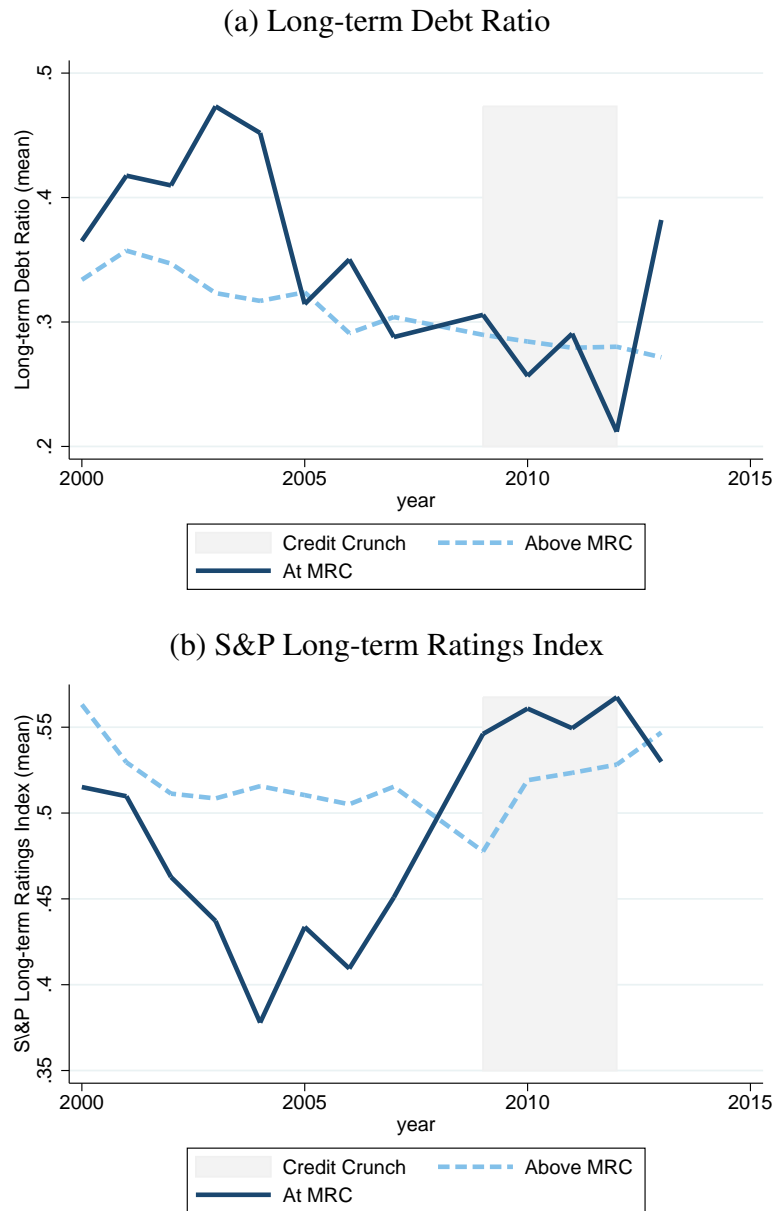
Notes. These figures show average debt ratio and ratings within year among firms that contributed at or below the minimum required contribution (solid line) and firms that contributed zero or above the minimum required contribution (dotted line). The underlying sample is all firms in the matched sample reported in Table 1. The debt ratios and long-term bond ratios are reported in Compustat. The long-term bond rating is transformed into a continuous index: a rating of AAA translates to 1 while a rating of D translates to 0. Each notch improvement in bond rating, such as an increase from B to B+, increases the index by .045. An index of .6 is equivalent to a bond rating of BBB-. Firms are categorized as contributing at or above the minimum required contribution with data from Form 5500, Schedule B/SB. No average is reported for 2008.

Figure 3.4: Firms Contributing at Minimum Required Contribution: Pre-recession sample



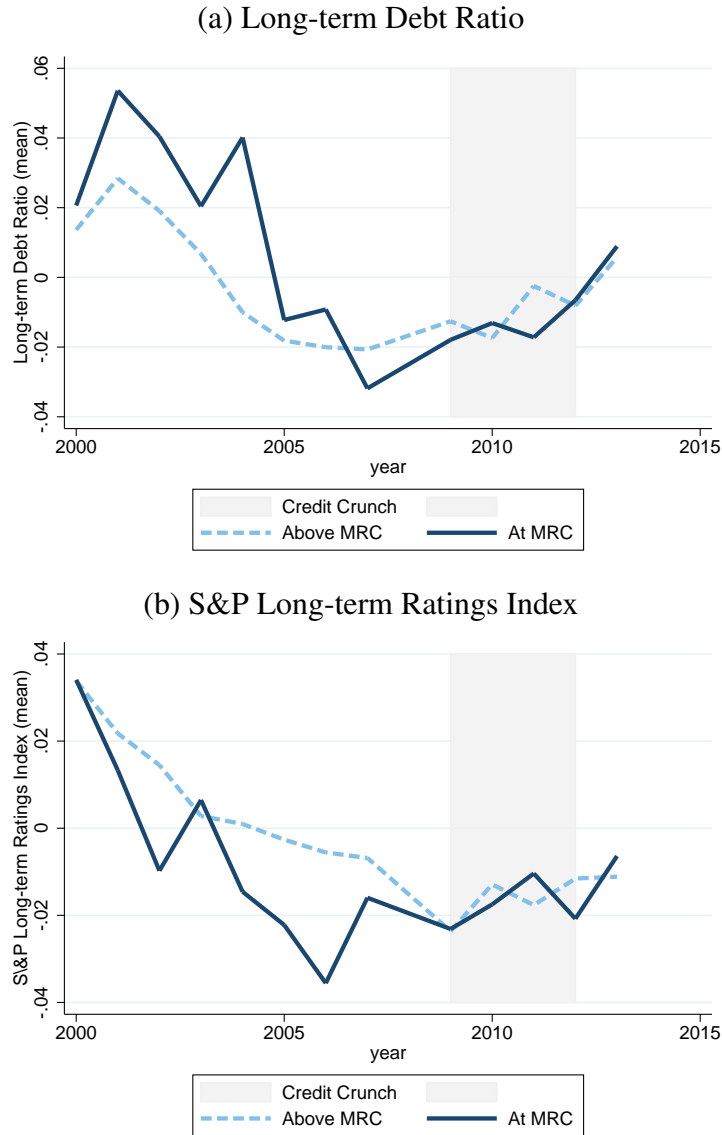
Notes. The sample underlying this figure is isolated to firms that contributed at or below the minimum required contribution to at least one pension plan between 2000 and 2007. The figure shows the fraction of firms in that sample that contributed at or below the minimum in each year from 2000 through 2013. 30 percent or fewer of these firms contributed at the minimum in any given year, suggesting that firms in the sample contribute at the minimum during some years and above the minimum in others. This provides observations of the behavior of any given firm both in years in which it contributes at the minimum and years in which it contributes above the minimum. A similar fraction of firms in this isolated sample contribute at the minimum during the credit crunch as before, implying that firms that contribute at the minimum before the recession are likely to do so after, as well.

Figure 3.5: Debt and Ratings of Firms Contributing at and above the Minimum: Pre-credit crunch sample



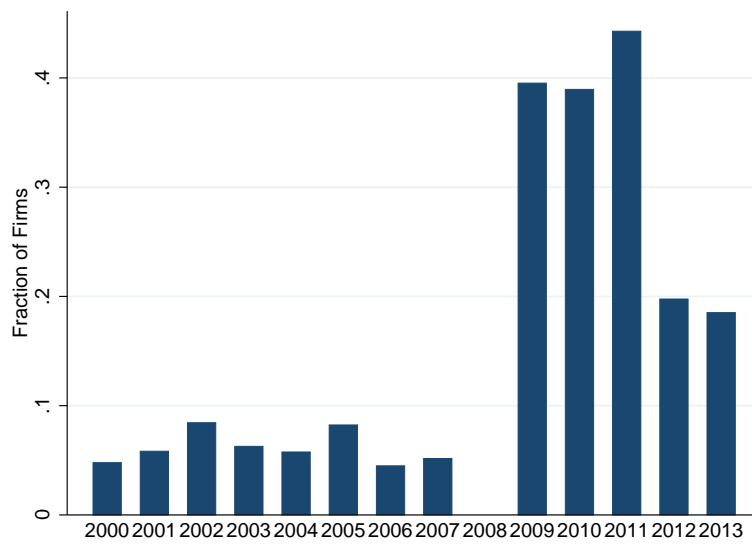
Notes. The sample underlying this figure is isolated to firms that contributed at or below the minimum required contribution to at least one pension plan in some year between 2000 and 2007. The figure shows the average debt ratio and ratings index within year among firms in that sample contributing at or below the minimum (solid line) or firms contributing zero or above the minimum (dotted line). The debt ratio and long-term bond index are reported in Compustat. The long-term bond rating is transformed into a continuous index: a rating of AAA translates to 1 while a rating of D translates to 0. Each notch improvement in bond rating, such as an increase from B to B+, increases the index by .045. An index of .6 is equivalent to a bond rating of BBB-. The lines plot the average within year and contribution group. No data is available for 2008.

Figure 3.6: Debt and Ratings of Firms Contributing at and above the Minimum Deviation from Mean within Firm



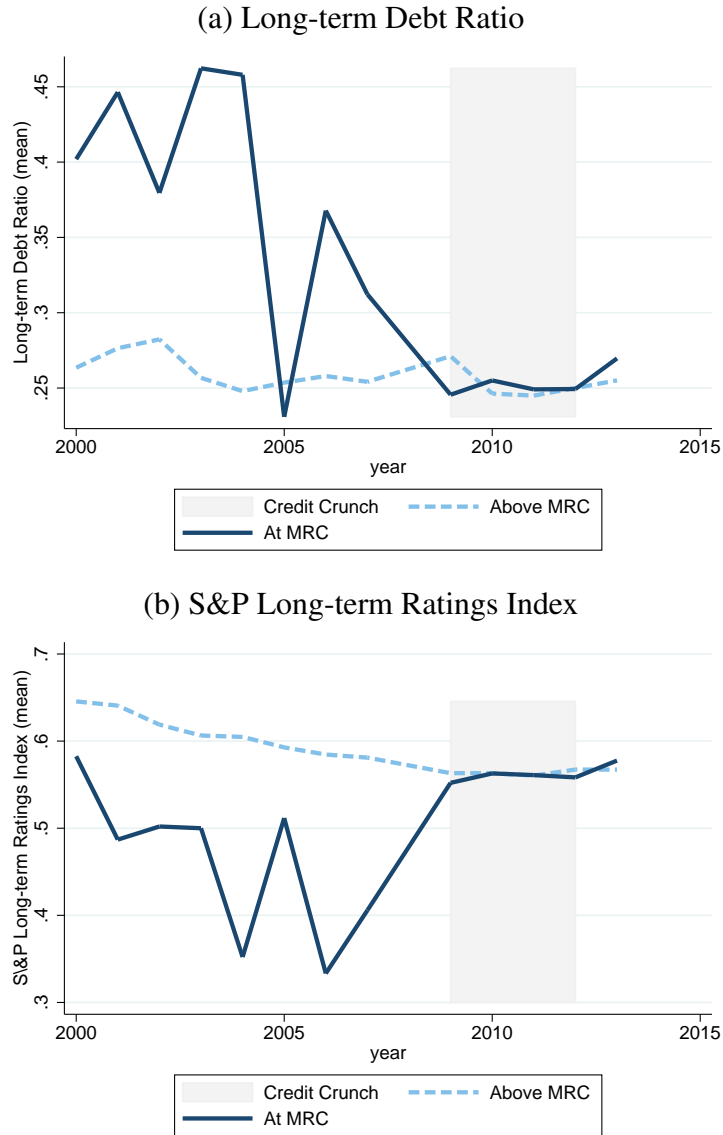
Notes. The sample underlying this figure is all firms in the matched sample reported in Table 1. The individual observations underlying this figure are deviations from the average debt or ratings within firm in years when the firm contributes at the minimum or above. The figure plots the average deviation from the mean within firm in years in which firms are contributing at and above the minimum required. The debt ratio and long-term bond index are reported in Compustat. The long-term bond rating is transformed into a continuous index: a rating of AAA translates to 1 while a rating of D translates to 0. Each notch improvement in bond rating, such as an increase from B to B+, increases the index by .045. An index of .6 is equivalent to a bond rating of BBB-. The lines plot the average within year and contribution group. No data is reported for 2008.

Figure 3.7: Firms Contributing at Minimum Required Contribution: Credit Crunch Sample



Notes. The sample underlying this figure is isolated to firms that contributed at or below the minimum required contribution to at least one pension plan between 2009 and 2011. The figure shows the fraction of firms in that sample that contributed at or below the minimum in each year from 2000 through 2013. Between 38 and 45 percent of firms in the sample contributed at the minimum in any given year during the recession. Fewer than 10 percent of firms contributed at the minimum prior to the recession, suggesting that many new firms contribute at the minimum during the recession.

Figure 3.8: Debt and Ratings of Firms Contributing at and above the Minimum: Credit crunch sample



Notes. The sample underlying this figure is isolated to firms that contributed at or below the minimum required contribution to at least one pension plan in some year between 2009 and 2011. The figure shows the average debt ratio and ratings index within year among firms in that sample contributing at or below the minimum (solid line) or firms contributing zero or above the minimum (dotted line). The debt ratio and long-term bond index are reported in Compustat. The long-term bond rating is transformed into a continuous index: a rating of AAA translates to 1 while a rating of D translates to 0. Each notch improvement in bond rating, such as an increase from B to B+, increases the index by .045. An index of .6 is equivalent to a bond rating of BBB-. The lines plot the average within year and contribution group. No data is available for 2008.

Table 3.1: Sample Selection from Compustat and Deal Scan Firms

	All Form 5500		Both		All Compustat
	Above MRC	At MRC	Above MRC	At MRC	
<hr/>					
MRC (\$ Thous)					
Mean	2,104	4,489	5,422	19,468	
Median	0	665	0	1,700	
Total Contributions (\$ Thous)					
Mean	8,182	3,278	21,802	11,782	
Median	516	557	749	1,417	
Pct. Contributing Zero	30	0	38	0	
<hr/>					
Total Participants					
Mean	3,975	2,010	11,252	7,822	
Median	621	426	2,491	1,358	
Funding Ratio					
Mean	99	89	105	87	
Median	93	86	98	85	
Total Liabilities (\$ Thous)					
Mean	152,590	87,885	671,905	774,034	
Median	13,550	10,103	114,305	143,676	
Pension Shortfall (\$ Thous)					
Mean	-43,264	2,210	-95,755	19,579	
Median	57	641	265	2,266	
<hr/>					
External Leverage					
Mean			.28	.32	.26
Median			.24	.26	.22
Pension Leverage					
Mean			.03	.15	.03
Median			.02	.03	.01
Firm Size					
Mean			7.53	7.31	6.88
Median			7.54	7.19	7.05
Tangibility					

Continued on next page

Table 3.1 – continued from previous page

	All Compustat		Both		All DealScan
	Above MRC	At MRC	Above MRC	At MRC	
Mean			.31	.3	.31
Median			.27	.27	.25
Market-to-Book Ratio					
Mean			1.68	1.53	2.59
Median			1.42	1.29	1.37
Profitability					
Mean			.09	.08	.13
Median			.05	.06	.07
N Obs	88,946	28,301	6,639	934	28,190
N Firms	9,381	3,725	1,047	474	3,806
N Plans	12,540	4,725			

Notes. The “All Form 5500” sample includes all defined benefit pension plans with more than 100 participants from 2000 through 2013, excluding those plans sponsored by firms in financial or utilities sectors (identified by SIC codes 6000-6999 and 4900-4999). The “All Compustat” sample includes all firms that sponsor defined benefit pensions in Compustat from 2000 through 2013, excluding firms in the financial or utilities sectors. Matched firms include firms that were able to be matched to pension plans using their identification number or a fuzzy name match. All variables are described in the data appendix.

Table 3.2: Pension Firms Contributing at and above the Minimum Required Contribution

	Contributing Zero or Above MRC			Contributing At or Below MRC		
	2001	2007	2010	2001	2007	2010
External Leverage						
Mean	.32	.26	.25	.42	.29	.26
Median	.28	.21	.21	.36	.23	.23
Ratings Index						
Mean	.58	.56	.55	.51	.45	.56
Median	.61	.57	.57	.48	.43	.57
Control Variables						
Funding Ratio						
Mean	110	99	88	86	80	87
Median	99	94	83	86	79	82
Pension Shortfall Ratio						
Mean	.01	0	.05	.04	.05	.05
Median	.01	.01	.03	.02	.02	.04
Pension Obligations (\$mil)						
Mean	1,246	2,300	2,185	491	276	4,034
Median	119	304	341	40	129	521
Market-to-Book Ratio						
Mean	1.59	1.83	1.62	1.5	1.62	1.54
Median	1.29	1.58	1.44	1.16	1.28	1.34
Firm Size						
Mean	7.11	7.84	7.77	6.31	6.96	7.98
Median	7.08	7.84	7.82	6.51	6.97	8.25
Tangibility						
Mean	.33	.29	.28	.34	.29	.29
Median	.3	.24	.24	.34	.25	.26
Profitability						
Mean	.06	.09	.11	.07	.08	.11
Median	.03	.05	.09	.02	.05	.08
Z-score						

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Table 3.2 – continued from previous page

	Contributing Zero or Above MRC			Contributing At or Below MRC		
	2001	2007	2010	2001	2007	2010
Mean	7,721	17,103	15,955	4,144	5,625	26,720
Median	1,595	4,444	3,829	638	1,006	5,403
Firm Age						
Mean	28	33	35	26	25	38
Median	30	36	37	27	20	44
Non-Pension Assets (\$mil)						
Mean	7,029	12,285	10,972	2,891	2,901	24,154
Median	1,080	2,793	2,806	554	917	4,227
Interest Coverage						
Mean	20	34	37	28	11	22
Median	5	9	10	3	5	7
Pct. Rated	57	68	65	47	55	72
Pct. Investment Grade	62	55	57	40	26	55
Pct. Zero Contrib	53	51	20	0	0	0
Pct. Neg Owner's Eq	9	5	9	19	16	10
N Firms	170	56	51	52	27	61

Notes. The sample presented includes all matched firms in 2001, 2007, and 2010. Variables, reported at the firm-year level, are described in the Data Appendix.

Table 3.3: Differences in the Ratio of Debt to Non-Pension Assets for Firms at and above the Minimum Required Contribution

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MRC (α)	.0367*** (.0101)	.058*** (.0128)	.0424*** (.0107)	.0607*** (.0134)	.0311*** (.00971)	.0459*** (.0123)	.0158* (.00841)	.025** (.0107)
MRC \times Credit Crunch (β)		-.0746*** (.0178)		-.0718*** (.0188)		-.0549*** (.0172)		-.034** (.0161)
$\alpha + \beta$		-.0165 (.0312)		-.0111 (.0326)		-.0090 (.0302)		-.0090 (.0257)
Shortfall to non-pen assets			.00809*** (.000339)	.00793*** (.000353)	.00963*** (.000504)	.0095*** (.000509)	.00775*** (.000787)	.00768*** (.000793)
Pension Funding Status			4.19e-08 (8.42e-08)	3.75e-08 (7.97e-08)	1.24e-09 (5.02e-08)	2.78e-09 (4.97e-08)	1.72e-08 (4.96e-08)	1.80e-08 (4.93e-08)
Log Pension Obligations			-.00489* (.00296)	-.00445 (.00295)	.00552 (.00498)	.00576 (.00497)	-.00132 (.00441)	-.00115 (.00441)
Market-to-book ratio					.00655 (.00686)	.00659 (.00684)	-.00266 (.00581)	-.00259 (.0058)
Firm size					.00241 (.00585)	.0026 (.00582)	.0133*** (.00503)	.0134*** (.00502)
Tangibility					.0412	.0412	.0379	.0378

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Table 3.3 – continued from previous page

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
					(.034)	(.0338)	(.0318)	(.0317)
Profitability					-.483***	-.481***	-.465***	-.463***
					(.0489)	(.0487)	(.0471)	(.0471)
Z-score					-4.92e-07***	-4.94e-07***	-4.59e-07***	-4.61e-07***
					(1.29e-07)	(1.29e-07)	(1.03e-07)	(1.03e-07)
Median Industry Leverage					.385**	.376**	.329*	.322*
					(.187)	(.186)	(.17)	(.169)
Negative Equity							.267***	.266***
							(.0312)	(.0312)
Observations	7526	7526	7246	7246	6342	6342	6342	6342
R^2	0.040	0.043	0.043	0.045	0.137	0.139	0.229	0.230

Notes. Table presents results from specification (7), with the ratio of debt to non-pension assets as the outcome variable. Standard errors, clustered at firm level, in parentheses; * $p < .10$, ** $p < .05$, *** $p < .01$. All specifications include year and industry fixed effects. MRC is an indicator of whether the firm contributed at the minimum to any of its pension plans in the previous year. Credit Crunch is an indicator for the years 2009, 2010, and 2011. Control variables are described in the Data Appendix. The hypotheses are $\alpha > 0$ and $\alpha + \beta = 0$. $\alpha > 0$ implies firms contributing at the MRC borrow more than firms in the same industry contributing above the MRC in years in which financing is easy. $\alpha + \beta_1\alpha$ implies that firms contributing at the MRC do not borrow as much more other firms in the industry not contributing at the MRC when financing is tight.

Table 3.4: Differences in S&P Long-term Bond Ratings for Firms Contributing at and above the Minimum Required Contribution

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MRC (α)	-.0434*** (.00935)	-.0696*** (.0109)	-.0375*** (.00756)	-.0489*** (.00894)	-.0282*** (.00656)	-.0376*** (.0077)	-.0266*** (.00628)	-.0351*** (.00733)
MRC \times Credit Crunch (β)		.0835*** (.0157)		.0408*** (.0136)		.0338*** (.011)		.0307*** (.0108)
$\alpha + \beta$		-.0139 (.0244)		-.0081 (.0216)		-.0037 (.0192)		-.0044 (.0193)
Shortfall to non-pen assets			-.747*** (.112)	-.745*** (.112)	-.393*** (.082)	-.391*** (.0818)	-.328*** (.0794)	-.326*** (.0792)
Pension Funding Status			-9.66e-08* (4.98e-08)	-9.36e-08* (5.33e-08)	-2.57e-08 (8.14e-08)	-2.31e-08 (8.44e-08)	-1.88e-08 (9.98e-08)	-1.65e-08 (1.02e-07)
Log Pension Obligations			.0419*** (.00355)	.0416*** (.00355)	-.00356 (.00387)	-.00376 (.00387)	-.00256 (.00382)	-.00274 (.00383)
Log Assets					.0563*** (.00524)	.0563*** (.00522)	.0544*** (.00524)	.0544*** (.00522)
Debt to Total assets					-.173*** (.0226)	-.172*** (.0225)	-.125*** (.025)	-.125*** (.0249)
Interest Coverage					.0000939	.0000942	.0000998	.0001

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Table 3.4 – continued from previous page

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
					(.0000589)	(.0000592)	(.0000617)	(.0000619)
Tangibility					-.0584**	-.0586**	-.052**	-.0522**
					(.024)	(.024)	(.0239)	(.0239)
Profitability					-.0897*	-.0924*	-.0639	-.0666
					(.0542)	(.0542)	(.0526)	(.0526)
Negative Equity							-.0737***	-.0733***
							(.0163)	(.0162)
Observations	4748	4748	4607	4607	4571	4571	4571	4571
R^2	0.022	0.030	0.290	0.291	0.529	0.530	0.540	0.542

Notes. Standard errors, clustered at firm level, in parentheses; * $p < .10$, ** $p < .05$, *** $p < .01$. Table presents results from specification (7), with the ratio of debt to non-pension assets as the outcome variable. All specifications include year and industry fixed effects. MRC is an indicator of whether the firm contributed at the minimum to any of its pension plans in the previous year. Credit Crunch is an indicator for the years 2009, 2010, and 2011. Control variables described in the Data Appendix. The hypotheses are $\alpha < 0$ and $\alpha + \beta = 0$. $\alpha < 0$ implies firms facing easy financing make riskier investments relative to the industry average than firms contributing above the minimum. $\alpha + \beta + \alpha = 0$ implies that firms contributing at the minimum face similar ratings relative to the industry average when financing is tight.

Table 3.5: Within-firm Differences in Debt and Ratings in Years when Firms Contribute at and above the Minimum Required Contribution

	Debt to non-pension assets				Ratings Index			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MRC (α)	.0216** (.00837)	.0235*** (.00871)	.0214** (.00966)	.0177* (.00922)	-.01** (.00505)	-.00745 (.00499)	-.00897* (.00475)	-.00833* (.0046)
MRC \times Credit Crunch (β)	-.0335** (.0131)	-.0336** (.015)	-.0354** (.0148)	-.0325** (.0146)	.00531 (.00676)	.00841 (.00784)	.0104 (.00731)	.0092 (.00709)
$\alpha + \beta$	-.0119 (.0351)	-.0101 (.0382)	-.0140 (.0401)	-.0148 (.0388)	-.0047 (.0142)	.0010 (.0151)	.0014 (.0150)	.0009 (.0145)
Firm and Year Fixed Effects	X	X	X	X	X	X	X	X
Pension Controls		X	X	X		X	X	X
Firm Controls			X	X			X	X
Neg. Equity Indicator				X				X
Observations	5838	5656	4949	4949	3528	3423	3398	3398
R^2	0.023	0.024	0.044	0.073	0.103	0.137	0.213	0.240

Notes. Standard errors, clustered at firm level, in parentheses; * $p < .10$, ** $p < .05$, *** $p < .01$. All specifications include year and firm fixed effects. MRC is an indicator of whether the firm contributed at the minimum to any of its pension plans in the given year. Credit Crunch is an indicator for the years 2009, 2010, and 2011. Control variables are described in the Data Appendix. The hypotheses are $\alpha > 0$ and $\beta < 0$ for Debt to non-pension assets, and $\alpha < 0$ and $\beta > 0$ for the ratings index: pension firms borrow more and make riskier investments in years in which they contribute at the MRC than in years when they contribute above the MRC. This difference narrows during the credit crunch.

APPENDIX A

Model Solution

The model solution consists of three mutually consistent decisions of the firm and the lender: the firm's financing decision in period 1, the lender's loan offering in period 1, and the firm's allocation decision in period 2. The following shorthand describes various measures related to the pension and production.

1. The expected return on the pension account:

$$\mathbb{E}\{1 + \rho\} = \ell(1 + \rho^S) + (1 - \ell)(1 + \rho^F)$$

2. The expected square return to the pension account

$$\mathbb{E}\{(1 + \rho)^2\} = \ell(1 + \rho^S)^2 + (1 - \ell)(1 + \rho^F)^2$$

3. The expected pension surplus

$$\begin{aligned}\mathbb{E}(S|C) &= \ell(1 + \rho^S)[(P + C) - D] + (1 - \ell)(1 + \rho^F)[(P + C) - D] \\ &= \mathbb{E}\{1 + \rho\}(P + C) - D\end{aligned}$$

4. The expected squared pension surplus

$$\mathbb{E}(S^2|C) = \ell[(1 + \rho^S)(P + C) - D]^2 + (1 - \ell)[(1 + \rho^F)(P + C) - D]^2$$

5. The expected amount of claimable pension assets in bankruptcy:

$$\mathbb{E}(\chi S|C) = \ell\chi^F[(1 + \rho^S)(P + C) - D]^2 + (1 - \ell)\chi^S[(1 + \rho^F)(P + C) - D]^2$$

6. Expected productivity:

$$\mathbb{E}(z) = pz^S + (1 - p)z^F$$

A.1 The Allocation Decision

The firm begins the second period with total operating funds Y (total operating funds $Y = E + B + X$), pension assets P and pension liabilities D . The firm faces a loan repayment b that must be made at the beginning of the third period. It allocates Y across investment I and pension contributions C before realizing risky returns. The firm that raised enough equity to avoid bankruptcy if production fails (safe agreement), and the firm that did not (risky agreement) face the following optimization problems:

A Safe Agreement	A Risky Agreement
The sponsor chooses I_S and C_S to maximize:	The sponsor chooses I_R and C_R to maximize:
$\left(\mathbb{E}(z)f(I) + (1+r)(Y - I - C) \right. \\ \left. + \mathbb{E}(X C) - \frac{\mu}{2}\mathbb{E}(S^2 C) - b_s \right)$	$p\left(z^S f(I) + (1+r)(Y - I - C) \right. \\ \left. + \mathbb{E}(X C) - \frac{\mu}{2}\mathbb{E}(S^2 C) - b_R \right)$
subject to	subject to
$Y \geq I_S + C_S$ multiplier: η_S	$Y \geq I_R + C_R$ multiplier: η_R
$I_S \geq 0$ $C_S \geq 0$ multipliers: ξ_I, ξ_C	$I_R \geq 0$ $C_R \geq 0$ multipliers: ξ_I, ξ_C
Solvency when production fails:	Bankruptcy when production fails:
$g^F(I_S, C_S) \geq b_s$	$g^F(I_R, C_R) < b_r$
	Solvency when production succeeds
	$g^S(I_R, C_R) \geq b_r$

Notes: The function $g^X(I, C)$ is the amount of funds the sponsor has on hand to pay expenses in period 3: $g^X(I, C) = z^X f(I) + (1+r)(Y - I - C) + \chi^F [(1 + \rho^F)(P + C) - D]$

A.1.1 The allocation decision when the sponsor chose a safe agreement

With a safe agreement, the sponsor will not go bankrupt if production fails. Ignoring the bankruptcy constraints, let the LaGrange multipliers be η_S (cash constraint), ξ_I and ξ_C (non-zero investment and contribution constraints). Note that $f(\bullet)$ satisfies the Inada conditions and $\xi_I = 0$. First-order conditions imply that investment and pension contributions

are such that:

Investment

$$f'(I) = \frac{1+r}{\mathbb{E}(z)} + \frac{\eta_s}{\mathbb{E}(z)} \quad (\text{A.1})$$

Contributions

$$C = \frac{\mathbb{E}\{1+\rho\} - (1+r)}{\mu\mathbb{E}\{(1+\rho)^2\}} + D \left(\frac{\mathbb{E}\{1+\rho\}}{\mathbb{E}\{(1+\rho)^2\}} \right) - P + \frac{\xi_C - \eta}{\mu\mathbb{E}\{(1+\rho)^2\}} \quad (\text{A.2})$$

Define:

$$\bar{C} = \frac{\mathbb{E}\{1+\rho\} - (1+r)}{\mu\mathbb{E}\{(1+\rho)^2\}} + D \left(\frac{\mathbb{E}\{1+\rho\}}{\mathbb{E}\{(1+\rho)^2\}} \right) - P \quad (\text{A.3})$$

A.1.2 Solutions

Two solutions to maximization problem (1) are of interest: the interior solution when the firm allocates some funds toward a safe asset ($\eta = 0$ and $Y > I + C$) and the constrained solution when the firm invests or contributes all of its funds ($\eta > 0$ and $Y = I + C$).¹

Interior When the firm allocates some funds to a safe asset, $\eta = 0$ and $I + C < Y$.

$$f'(I_S^*) = \frac{1+r}{\mathbb{E}(z)} \quad (\text{A.4})$$

$$C_S^* = \max \{ \bar{C}, 0 \} \quad (\text{A.5})$$

Constrained Let I_{SC}^* and C_{SC}^* be the firm's allocation when $Y < I_S^* + C_S^*$ or $\eta_s > 0$. In this case, the firm does not allocate any funds toward the safe asset. Further suppose that $C_S^* > 0$ (note that if $C_S = 0$, $C_{SC}^* = 0$ and $I_{SC}^* = Y$). The first-order conditions become:

$$f'(I_{SC}^*) = \frac{1+r}{\mathbb{E}(z)} + \frac{\eta}{\mathbb{E}(z)} \quad (\text{A.6})$$

$$C_{SC}^* = \bar{C} - \frac{\eta}{\mu\mathbb{E}\{(1+\rho)^2\}} \quad (\text{A.7})$$

¹This appendix does not solve solutions in when the bankruptcy constraint binds. Those solutions are available upon request, but do not contribute substantially to the understanding of the model: the unconstrained sponsor will choose an allocation that allows it to go bankrupt rather than adopt one of these corner solutions.

Solve this system of equations for I_{SC}^* and note that $C_{SC}^* = Y - I_{SC}^*$ to find that I_{SC}^* solves the equation:

$$I_{SC}^* - \frac{f'(I_{SC}^*)\mathbb{E}(z) - (1+r)}{\mu\mathbb{E}\{(1+\rho)^2\}} = Y - \bar{C} \quad (\text{A.8})$$

When $f(I)$ has decreasing returns to scale, the left-hand side of equation A.8 is increasing in I_{SC}^* .² Therefore, a solution exists on the interval $[0, Y]$ for a given Y if:

$$Y - \left(\frac{\mathbb{E}(z)f'(Y) - (1+r)}{\mu\mathbb{E}\{(1+\rho)^2\}} \right) > Y - \bar{C} > 0 - \left(\frac{\mathbb{E}(z)f'(0) - (1+r)}{\mu\mathbb{E}\{(1+\rho)^2\}} \right)$$

The Inada conditions imply $f'(0) = \infty$; a solution exists for all positive values of Y .

A.1.3 The allocation decision when the sponsor chose a risky agreement

With a risky agreement, the sponsor will go bankrupt if production fails but remain solvent when production succeeds. Again ignoring the bankruptcy constraints, let the LaGrangian multipliers be η_R (cash constraint), ξ_I and ξ_C (non-zero investment and contribution constraints). Note that $\xi_I = 0$; the first-order conditions are:

Investment

$$f'(I) = \left(\frac{1+r}{z^S} \right) + \frac{\eta_R}{pz^S} \quad (\text{A.9})$$

Contributions

$$C = \bar{C} + \frac{\xi_C - \eta_R}{\mu\mathbb{E}\{(1+\rho)^2\}} \quad (\text{A.10})$$

Note that the first-order condition for contributions is the same as that under a safe agreement (equation A.10 is the same as equation A.2), but the first-order condition for investment differs (equation A.9 differs from equation A.1).

A.1.4 Solutions

Again, two solutions are of interest: the interior solution where $\eta_R = 0$ and $Y > I + C$, and the constrained solution when $\eta_R > 0$ and $Y = I + C$.

²Note that $\frac{\mathbb{E}(z)}{\mu\mathbb{E}\{(1+\rho)^2\}} > 0$ and $f''(I_{SC}^*) < 0$, implying that $\frac{\partial(LHS)}{\partial I} = 1 - \frac{\mathbb{E}(z)}{\mu\mathbb{E}\{(1+\rho)^2\}} f''(I_{SC}^*) > 1$

Interior When the firm allocates some funds to a safe asset, $\eta_R = 0$ and $I + C < Y$.

$$f'(I_R^*) = \frac{1+r}{z^s} \quad (\text{A.11})$$

$$\bar{C} = \max\{\bar{C}, 0\} \quad (\text{A.12})$$

Constrained Let I_{RC}^* and C_{RC}^* be the constrained firm's allocation when $Y < I_R^* + C_R^*$ ($\eta_R > 0$) and the firm does not allocate any funds to the safe asset. Further suppose that $C_R^* > 0$. Then:

$$f'(I_{RC}^*) = \frac{1+r}{z^s} + \frac{\eta_R}{pz^s} \quad (\text{A.13})$$

$$C_{RC}^* = \bar{C} - \frac{\eta_R}{\mu\mathbb{E}\{(1+\rho)^2\}} \quad (\text{A.14})$$

Solve this system of equations for I_{RC}^* and note that $C_{RC}^* = Y - I_{RC}^*$ to find that I_{RC}^* solves the equation:

$$I_{RC}^* - \left(\frac{p(z^s f'(I_{RC}^*) - (1+r))}{\mu\mathbb{E}\{(1+\rho)^2\}} \right) = Y - \bar{C} \quad (\text{A.15})$$

The RHS of the above equation is increasing in I_{RC}^* , and a solution exists if:

$$Y - \left(\frac{p(z^s f'(Y) - (1+r))}{\mu\mathbb{E}\{(1+\rho)^2\}} \right) > Y - \bar{C} > 0$$

A.2 The Schedule of Loans

A.2.1 A safe agreement

Suppose the firm has raised equity E and requests a loan of size B from the lender. Let (I, C) be the firm's known allocation when the lender sets a required repayment of b . The lender offers a safe loan when the firm will avoid bankruptcy if production fails:

$$z^F f(I) + (1+r)(X + E + B - I - C) + \mathbb{E}(\chi S|C) \geq (1+r)b \quad (\text{A.16})$$

The lender, who operates in a competitive market and always gets repaid, will set the required repayment equal to his opportunity cost of funds:

$$b = (1 + r)B \quad (\text{A.17})$$

Given the firm's allocation decisions described above, an equilibrium in which the lender offers a safe rate is possible when equations A.16 and A.17 are consistent, or:

$$(1 + r)(X + E) \geq (1 + r)(I_S^* + C_S^*) - z^F f(I_S^*) - \mathbb{E}(\chi S | C_S^*) \quad (\text{A.18})$$

A.2.2 A risky agreement

Suppose the firm has raised equity E and requests a loan of size B from the lender. Let (I, C) be the firm's known allocation when the lender sets a required repayment of b . The lender offers a risky loan when the firm avoids bankruptcy when production succeeds, but faces bankruptcy when production fails:

$$z^F f(I) + (1 + r)(X + E + B - I - C) + \chi^F [(1 + \rho^F)(P + \bar{C}) - D] < (1 + r)b \quad (\text{A.19})$$

$$z^S f(I) + (1 + r)(X + E + B - I - C) + \chi^S [(1 + \rho^F)(P + \bar{C}) - D] \geq (1 + r)b \quad (\text{A.20})$$

The lender sets the borrowing premium so that it breaks even in expectation. For a given amount borrowed, B , the lender's expected payoff will be:

$$\mathbb{E}_1(W(b|B, I(B, b), C(B, b))) = pb + (1 - p)z^F f(I) + (1 + r)(B + X + E - I - C) + \mathbb{E}(\chi S | C)$$

In the above equation, I and C are known, non-decreasing functions of B and non-increasing function of b . The lender sets b so that:

$$b = (1 + r)B + \frac{1 - p}{p} \left\{ \underbrace{(1 + r)(I - X - E) - z^F f(I)}_{\text{Standard without pension}} + \underbrace{(1 + r)C - \mathbb{E}(\chi S | C)}_{\text{Premium due to pension}} \right\} \quad (\text{A.21})$$

Given the firm's optimal allocation under a risky agreement, the lender offers a risky loan when equations A.19, A.20, and A.21 are mutually consistent, or:

$$\begin{aligned}
(1+r)(I_R^* + C_R^*) - z^F f(I_R^*) - \mathbb{E}(S|C_R^*) &> (1+r)(X + E) \\
&\geq (1+r)(I_R^* + C_R^*) - z^S f(I_R^*) - \mathbb{E}(S|C_R^*)
\end{aligned}
\tag{A.22}$$

A.3 The Financing decision

In the first period, the sponsor chooses among a schedule of safe and risky loan agreements. On the extensive margin, it chooses between a safe and risky loan; on the intensive margin it chooses how much debt and equity to raise.

A.3.1 Safe Financing: how much will the firm borrow and equity will it raise?

Suppose the firm raises enough equity to avoid bankruptcy when production fails. The firm faces borrowing rate $1+r$. Suppose the shareholder receives a safe return on outside investments of $1+r^o$; this is the cost of equity. The firm's expected payoff is:

$$V^S = (1+r)(X + E + B - I - C) + \mathbb{E}(S|C) - \frac{\mu}{2} \mathbb{E}(S^2|C) + \mathbb{E}(z)(I) - E(1+r^o) - \underbrace{b}_{=(1+r)B}
\tag{A.23}$$

I and C are determined in the second period as a function of the financing position (B, E) . As shown in section A.1, investment and contributions are chosen according to equations (A.1) and (A.2). Implicit differentiation of these equations shows:

$$\frac{\partial I}{\partial E} = \frac{\partial I}{\partial B} = \begin{cases} 0 & \text{if } \eta = 0 \\ \frac{\mu \mathbb{E}\{(1+\rho)^2\}}{\mu \mathbb{E}\{(1+\rho)^2\} - \mathbb{E}(z)f''(I)} & \text{if } \eta > 0 \end{cases}
\tag{A.24}$$

$$\frac{\partial C}{\partial E} = \frac{\partial C}{\partial B} = \begin{cases} 0 & \text{if } \eta = 0 \\ \frac{-\mathbb{E}(z)f''(I)}{\mu \mathbb{E}\{(1+\rho)^2\} - \mathbb{E}(z)f''(I)} & \text{if } \eta > 0 \end{cases}
\tag{A.25}$$

The firm considers the borrowing rate as a function of the amount borrowed. Let \underline{E} be the minimum equity required for the lender to offer a safe loan. The firm's optimization problem in the first period is:

$$\begin{aligned}
&\max_{E, B} V^S(E, B, I(B, E), C(B, E)) \\
&\text{subject to } X + E + B \geq C + I, \quad E \geq \underline{E}, \quad B \geq 0, \quad C \geq 0, \quad I \geq 0
\end{aligned}$$

Let ϕ be the multiplier on the first constraint, and λ_x be the multiplier on the non-zero constraint with respect to variable x . The first order conditions for E and B :

$$\lambda_E = (1 + r^o) - (1 + r) - \phi \left\{ 1 - \left(\frac{\partial I}{\partial B} + \frac{\partial C}{\partial B} \right) \right\} - \frac{\partial I}{\partial E} \mathcal{G} - \frac{\partial C}{\partial E} \mathcal{H} \quad (\text{A.26})$$

$$\lambda_B = -\phi \left\{ 1 - \left(\frac{\partial I}{\partial B} + \frac{\partial C}{\partial B} \right) \right\} - \frac{\partial I}{\partial B} \mathcal{G} - \frac{\partial C}{\partial B} \mathcal{H} \quad (\text{A.27})$$

where

$$\mathcal{G} = f'(I)\mathbb{E}(z) - (1 + r) \quad (\text{A.28})$$

$$\mathcal{H} = \frac{\partial \mathbb{E}(S|C)}{\partial C} - \frac{\mu}{2} \left(\frac{\partial \mathbb{E}(S^2|C)}{\partial C} \right) - (1 + r) + \lambda_C \quad (\text{A.29})$$

Note that $\frac{\partial I}{\partial B} = \frac{\partial I}{\partial E}$ and $\frac{\partial C}{\partial B} = \frac{\partial C}{\partial E}$ are determined in the second period according to equations (A.24) and (A.25). Therefore, there are two potential classes of solutions for equations (A.26) and (A.27): (1) interior, where $\eta = 0$ and $B + E$ is large, and (2) constrained, where $\eta > 0$ and $B + E$ is small.

Interior solution Consider first the case in which $\eta = 0$, implying $\phi = 0$ and $\frac{\partial I}{\partial B} = \frac{\partial I}{\partial E} = \frac{\partial C}{\partial B} = \frac{\partial C}{\partial E} = 0$. The first-order conditions with respect to equity and debt reduce to:

$$\lambda_E = (1 + r^o) - (1 + r) \quad (\text{A.30})$$

$$\lambda_B = 0 \quad (\text{A.31})$$

If the shareholder receives the same safe return inside and outside of the firm ($r^o = r$) the firm is indifferent between using equity and debt; both are used: $\lambda_E = \lambda_B = 0$. If the shareholder receives a higher return outside of the firm than inside, $1 + r^o > 1 + r$, and $\lambda_E > 0$ while $\lambda_B = 0$: debt, but not equity, is used. The firm borrows an amount B^* so that $X + B^* \geq I_S^* + C_S^*$.

Firm allocates at constrained solution Consider the case in which $\eta > 0$, implying $\phi > 0$ and $\frac{\partial I}{\partial E} = \frac{\partial I}{\partial B} > 0$ and $\frac{\partial C}{\partial E} = \frac{\partial C}{\partial B} > 0$. Further, $\frac{\partial I}{\partial E} + \frac{\partial C}{\partial E} = \frac{\partial I}{\partial B} + \frac{\partial C}{\partial B} = 1$. The firm's second-period optimization (equations A.1 and A.2) implies that $\mathcal{G} = 0$ and $\mathcal{H} = 0$,

leading to the following first-order conditions for debt and equity:

$$\lambda_E = (1 + r^o) - (1 + r) - \phi \quad (\text{A.32})$$

$$\lambda_B = -\phi \quad (\text{A.33})$$

As LaGrange multipliers, $\lambda_B \geq 0$ and $\phi \geq 0$ requiring $\lambda_B = 0$. A firm is indifferent between debt and equity when $r = r^o$ and finances only with debt when $r^o > r$.

A.3.2 Risky Financing: bankruptcy when production fails

Now suppose the firm does not raise enough equity to face bankruptcy when production fails. In this case, the borrowing rate b_r is described in equation (A.21). The firm's expected payoff in such an equilibrium is:

$$\begin{aligned} V^R = & p\{(1 + r)(X + E + B - I - C) + \mathbb{E}(S|C) - \frac{\mu}{2}\mathbb{E}(S^2|C) + z^s f(I)\} \\ & - E(1 + r^o) - pb_r \end{aligned}$$

Total differentiation of b_R with respect to debt and equity yields:

$$\frac{\partial b_R}{\partial B} = (1 + r) + \frac{1 - p}{p} \left(\frac{\partial I}{\partial B} \left((1 + r) - z^F f'(I) \right) + \frac{\partial C}{\partial B} \left((1 + r) - \frac{\partial \mathbb{E}(\chi S|C)}{\partial C} \right) \right) \quad (\text{A.34})$$

$$\frac{\partial b_R}{\partial E} = \frac{1 - p}{p} \left(\frac{\partial I}{\partial E} \left((1 + r) - z^F f'(I) \right) + \frac{\partial C}{\partial E} \left((1 + r) - \frac{\partial \mathbb{E}(\chi S|C)}{\partial C} \right) \right) \quad (\text{A.35})$$

As shown in section A.1.2, investment and contributions are determined as a function of the financing position (B, E) according to equations (A.9) and (A.10). Implicit differentiation shows:

$$\frac{\partial I}{\partial E} = \frac{\partial I}{\partial B} = \begin{cases} 0 & \text{if } \eta = 0 \\ \frac{\mu \mathbb{E}\{(1+\rho)^2\}}{\mu \mathbb{E}\{(1+\rho)^2\} - z^s f''(I)} & \text{if } \eta > 0 \end{cases} \quad (\text{A.36})$$

$$\frac{\partial C}{\partial E} = \frac{\partial C}{\partial B} = \begin{cases} 0 & \text{if } \eta = 0 \\ \frac{-\mathbb{E}(z) f''(I)}{\mu \mathbb{E}\{(1+\rho)^2\} - z^s f''(I)} & \text{if } \eta > 0 \end{cases} \quad (\text{A.37})$$

Note that $\frac{\partial I}{\partial B} = \frac{\partial I}{\partial E}$ and $\frac{\partial C}{\partial B} = \frac{\partial C}{\partial E}$, implying that $\frac{\partial b_R}{\partial B} = 1 + r + \frac{\partial b_R}{\partial E}$. The firm chooses financing in the first period according to the optimization problem:

$$\begin{aligned} & \max_{E, B} V^R \\ & \text{subject to } X + E + B \geq C + I, \quad E \geq 0, \quad B \geq 0, \quad C \geq 0, \quad I \geq 0 \end{aligned}$$

Let ϕ be the multiplier on the first constraint, and λ_x be the multiplier on the non-zero constraint with respect to variable x . The first-order conditions with respect to equity and debt imply:

$$\begin{aligned} \lambda_E &= (1 + r^o) + p \frac{\partial b_R}{\partial E} - p(1 + r) - \phi \left(1 - \left(\frac{\partial C}{\partial E} + \frac{\partial I}{\partial E} \right) \right) - \frac{\partial I}{\partial E} \mathcal{J} - \frac{\partial C}{\partial E} \mathcal{K} \\ \lambda_B &= p \frac{\partial b_R}{\partial B} - p(1 + r) - \phi \left(1 - \left(\frac{\partial C}{\partial B} + \frac{\partial I}{\partial B} \right) \right) - \frac{\partial I}{\partial B} \mathcal{J} - \frac{\partial C}{\partial B} \mathcal{K} \end{aligned}$$

Where

$$\mathcal{J} = p(z^s f'(I) - (1 + r))$$

$$\mathcal{K} = p \left(\frac{\partial \mathbb{E}(S|C)}{\partial C} - \frac{\mu}{2} \frac{\partial \mathbb{E}(S^2|C)}{\partial C} - (1 + r) \right) + \lambda_C$$

The firm's allocation across investment and contributions in the second period is determined by how much it borrows in the first period. The firm may either (1) borrow enough to allocate at the interior solution: $I = I_R^* > I_S^*$ and $C = C_R^*$, implying that $\phi = 0$, or (2) borrow less and allocate according to the constrained solution: $I = I_{RC}^*$ and $C = C_{RC}^*$, implying that $\phi > 0$.

The firm allocates at the interior solution If $\phi = 0$, then $\eta = 0$ in equations (A.36) and (A.37) and $\frac{\partial I}{\partial E} = \frac{\partial I}{\partial B} = \frac{\partial C}{\partial E} = \frac{\partial C}{\partial B} = 0$. The equilibrium debt and equity choice satisfies the equations:

$$\lambda_B = p \left(\frac{\partial b_R}{\partial B} - (1 + r) \right) = p \frac{\partial b_R}{\partial E}$$

$$\begin{aligned} \lambda_E &= (1 + r^o) - p(1 + r) + p \frac{\partial b_R}{\partial E} \\ &= (1 + r^o) - p(1 + r) + \lambda_B \end{aligned}$$

Suppose $r^o = r$. Then $(1 + r^o) - p(1 + r) > 0$. With $\lambda_B \geq 0$, then $\lambda_E > 0$. The firm is no longer indifferent between debt and equity finance; an equilibrium in which the firm raises non-zero funds in the first period exists only if the firm raises debt but not equity ($\lambda_B = 0$ and $\lambda_E > 0$). The firm raises enough debt so that $X + B \geq I_R^* + C_R^*$.

The firm allocates at a constrained solution If $\phi > 0$, then $\eta > 0$ in equations A.9 and A.10. Those equations further also allow us to solve for \mathcal{J} and \mathcal{K} , leading to:

$$\lambda_E = \begin{cases} 1 + r^o - p(1 + r - \frac{\partial b_r}{\partial E}) & \text{if } \lambda_C = 0 \\ 1 + r^o - p(1 + r - \frac{\partial b_r}{\partial E}) - \frac{\partial C}{\partial E}(1 - p)\lambda_c & \text{if } \lambda_C > 0 \end{cases} \quad (\text{A.38})$$

$$\lambda_B = \begin{cases} p(\frac{\partial b_r}{\partial B} - (1 + r)) & \text{if } \lambda_C = 0 \\ p(\frac{\partial b_r}{\partial B} - (1 + r)) - \frac{\partial C}{\partial B}(1 - p)\lambda_c & \text{if } \lambda_C > 0 \end{cases} \quad (\text{A.39})$$

$$\lambda_B = \begin{cases} p\frac{\partial b_R}{\partial E} & \text{if } \lambda_C = 0 \\ p\frac{\partial b_r}{\partial E} - \frac{\partial C}{\partial B}(1 - p)\lambda_c & \text{if } \lambda_C > 0 \end{cases} \quad (\text{A.40})$$

Since $\frac{\partial C}{\partial B} = \frac{\partial I}{\partial E}$, we again have: $\lambda_E = 1 + r^o - p(1 + r) + \lambda_B$. By reasoning analogous to the case in which the levered firm allocates at the interior solution, the firm will raise only debt when $1 + r^o = 1 + r$. To determine the amount of debt that the firm will raise, note that a non-trivial solution to the optimization problem exists only when $\lambda_B = 0$, or:

$$\lambda_B = 0 = \frac{1 - p}{p} \left(\frac{\partial I}{\partial E} \left((1 + r) - z^F f'(I) \right) + \frac{\partial C}{\partial E} \left((1 + r) - \frac{\partial \mathbb{E}(\chi S | C)}{\partial C} - p\lambda_C \right) \right) \quad (\text{A.41})$$

Note that $\frac{\partial I}{\partial B} = 1 - \frac{\partial C}{\partial B}$. $\lambda_B = 0$ when:

$$\begin{aligned} 0 &= (1 + r) + z^F f'(I) \left(\frac{\partial C}{\partial E} - 1 \right) - \frac{\partial C}{\partial E} \left(\frac{\partial \mathbb{E}(\chi S | C)}{\partial C} - p\lambda_C \right) \\ 0 &= (1 + r) - z^F f'(I) \frac{\partial I}{\partial E} - \frac{\partial C}{\partial E} \left(\frac{\partial \mathbb{E}(\chi S | C)}{\partial C} - p\lambda_C \right) \end{aligned} \quad (\text{A.42})$$

Suppose the firm faces enough of a pension deficit so that $\lambda_C = 0$. Further, the total amount the firm expects to be able to revert from the pension to service debt is 0; this is true if the pension will be in deficit regardless of the return on pension assets given the optimal contribution. In this case, the firm borrows exactly enough so that $I = I_{RC}$ satisfies the

following equation:

$$f'(I) = \frac{1+r}{z^F \frac{\partial I}{\partial E}} \quad (\text{A.43})$$

Noting that $\frac{\partial I}{\partial E} = \frac{\mu \mathbb{E}\{(1+\rho)^2\}}{\mu \mathbb{E}\{1+\rho\} - z^S f''(I)}$, the firm chooses B so that $I = I_{RC}^*$ satisfies:

$$f'(I) = \frac{(1+r) \left(\mu \mathbb{E}\{(1+\rho)^2\} - z^S f''(I) \right)}{z^F \mu \mathbb{E}\{(1+\rho)^2\}} \quad (\text{A.44})$$

The paper defines this optimal level of investment $I_R^* - \Delta I$. The marginal return to contributions will be equal to the marginal return to investment when $I = I - \Delta I$. The pension contribution, referred to as $\bar{C} - \Delta C$ in the paper, is then determined according to equation A.10:

$$C_{RC}^* = \bar{C} - \frac{(1+r)p(1-p)(z^S - z^F)}{\mathbb{E}(z) \mu \mathbb{E}\{(1+\rho)^2\}} \quad (\text{A.45})$$

When the firm chooses to constrain its financing $\phi > 0$, it borrows B such that $X + B = I_R^* - \Delta I + \bar{C} - \Delta C$, and it allocates funds in the second period so that: $(I^*, C^*) = (I_R^* - \Delta I, \max\{\bar{C} - \Delta C, 0\})$.

A.3.3 Endogenous Choice of Financing

These results suggest three potential optimal financing positions, described as E1, D1, and D2 in Figure 3. Each position is associated with a specific allocation of funds between investment and contributions. The parameters describing the firm's production and pension processes dictate which of the three positions the firm chooses.

When does the levered firm choose to over-invest rather than under-contribute?

The firm chooses to borrow enough to over-invest when the agency cost of over-investment is less than the regulatory cost of under-contributions. Suppose a sponsor has chosen a risky agreement. The sponsor's payoff from borrowing enough to over invest:

$$\begin{aligned} V_U^B = & (1+r)X - (1+r)\{I_R^* + \bar{C}\} + f(I_R^*)\mathbb{E}(z) \\ & + p\{\mathbb{E}(S|\bar{C}) - \frac{\mu}{2}\mathbb{E}(S^2|\bar{C})\} + (1-p)\mathbb{E}(\chi S|\bar{C}) \end{aligned}$$

The sponsor's payoff from constraining borrowing to under-contribute:

$$V_C^B = (1+r)X - (1+r)\{(I_R^* - \Delta I) + (\bar{C} - \Delta C)\} + f(I_R^* - \Delta I)\mathbb{E}(z) \\ + p\{\mathbb{E}(S|\bar{C} - \Delta C) - \frac{\mu}{2}\mathbb{E}(S^2|\bar{C} - \Delta C)\} + (1-p)\mathbb{E}(\chi S|\bar{C} - \Delta C)$$

It will be worthwhile for the firm to borrow less when $V_C^B > V_U^B$. This is true when:

$$\left(\mathbb{E}(z)f(I_R^* - \Delta I) - (1+r)(I_R^* - \Delta I)\right) - \left(\mathbb{E}(z)f(I_R) - (1+r)(I_R)\right) > \\ p\{\mathbb{E}(S|\bar{C}) - \mathbb{E}(S|\bar{C} - \Delta C)\} - p\left\{\frac{\mu}{2}\mathbb{E}(S^2|\bar{C}) - \frac{\mu}{2}\mathbb{E}(S^2|\bar{C} - \Delta C)\right\} \quad (\text{A.46}) \\ + (1-p)\{\mathbb{E}(\chi S|\bar{C}) - \mathbb{E}(\chi S|\bar{C} - \Delta C)\} - (1+r)\Delta C$$

The left-hand side of this equation represents the cost of over-production. The right-hand side represents the cost of under-contributions. The firm borrows enough to over invest when it is less costly to over-invest than under-contribute.

The cost of over-production When the sponsor borrows under a risky arrangement, the lender sets the borrowing premium so that the sponsor fully internalize the cost of over-production. Therefore, when the sponsor chooses to over-invest, it suffers the same cost associated with production when it borrows under a risky agreement as when it borrows under a safe agreement—ie., the full cost of over-production:

$$OPCost = \left(\mathbb{E}(z)f(I_S^*) - (1+r)(I_S^*)\right) - \left(\mathbb{E}(z)f(I_R^*) - (1+r)(I_R^*)\right) \quad (\text{A.47})$$

Since I_S^* is the optimal solution when the firm internalizes the upside and downside risk of production, $\mathbb{E}(z)f(I_S^*) - (1+r)(I_S^*) > \mathbb{E}(z)f(I_R^*) - (1+r)(I_R^*)$. Therefore, the cost of over-production is positive.

The cost of under-contributing The optimal level of contributions to the pension account, regardless of whether the firm borrows under a safe or risky arrangement, is \bar{C} . Contributing less than that amount to the pension account will incur some costs. They are:

$$\begin{aligned}
UCCost = & \underbrace{p\{\mathbb{E}(S|\bar{C}) - \mathbb{E}(S|\bar{C} - \Delta C)\}}_{\text{Decrease in pension surplus}} - \underbrace{p\left\{\frac{\mu}{2}\mathbb{E}(S^2|\bar{C}) - \frac{\mu}{2}\mathbb{E}(S^2|\bar{C} - \Delta C)\right\}}_{\text{Change in implicit pension cost}} \\
& + \underbrace{(1-p)\{\mathbb{E}(\chi S|\bar{C}) - \mathbb{E}(\chi S|\bar{C} - \Delta C)\}}_{\text{Change in borrowing premium}} - (1+r)\Delta C
\end{aligned} \tag{A.48}$$

The decrease in pension surplus will be positive when the firm contributes less to the pension account. However, the change in the implicit pension cost and the change in borrowing premium may be positive or negative, according to pension parameters. When simplified into the underlying pension parameters, the cost to under-contributing to the pension account is:

$$\begin{aligned}
UCCost = & \Delta C \left(p\mathbb{E}(1 + \rho) - (1 + r) + (1 - p)\mathbb{E}\{\chi(1 + \rho)\} \right) \\
& - p\mu\Delta C\mathbb{E}\{(1 + \rho)S|\bar{C}\} - \frac{p\mu(\Delta C)^2}{2}\mathbb{E}\{1 + \rho\}
\end{aligned}$$

The cost to under-contributing is positive, and therefore, potentially larger than the cost to over-investment, when the firm faces a large expected pension deficit: the second term in the equation above is negative. The cost may also be increasing in μ , the regulatory burden of lower contributions, when the firm expects a pension deficit. This identifies two indicators of a sponsor with a high cost of under-contributing to the pension account: a large pension deficit or a high regulatory burden of lower contributions. In the empirical analysis, a firm with an optimal contribution below the federally required minimum contribution is assumed to face a high regulatory burden of contributing less.

The choice of risky borrowing without a pension A firm without a pension cost will face a zero cost of under-contributing. Therefore, the positive cost of over-contributing will be larger than the zero cost of under-contributing: the firm constrains its borrowing in the first period so that it optimally allocates I_S^* in the second period.

When does the firm choose a risky over a safe financing position?

The firm's payoff when it chooses a risky financing position is:

$$V^B = \max(V_U^B, V_C^B)$$

The firm's payoff when it chooses a safe financing agreement is:

$$V^S = (1 + r)(X - I - C) + \mathbb{E}(S|C) - \frac{\mu}{2}\mathbb{E}(S^2|C) + \mathbb{E}(z)(I)$$

The firm chooses safe financing over risky financing when $V^B > V^E$.

A firm that over-invests under a risky agreement If the cost to over-investment is lower than the cost to under-contributions, the sponsor knows that the ideal risky financing arrangement will allow it to over-invest in production. The firm chooses a safe agreement when:

$$\begin{aligned} & \left(\mathbb{E}(z)f(I_S^*) - (1 + r)I_S^* \right) - \left(\mathbb{E}(z)f(I_R^*) - (1 + r)I_R^* \right) \\ & > (1 - p) \left(\frac{\mu}{2}\mathbb{E}(S^2|\bar{C}) - \mathbb{E}(\chi S|\bar{C}) - \mathbb{E}(S|\bar{C}) \right) \end{aligned}$$

The left-hand side of this inequality is the familiar cost of over-investment. The right-hand side is the cost associated with the pension account that the sponsor avoids if it enters bankruptcy and is larger when the firm expects a pension deficit. The paper refers to this as the pension cost avoided in bankruptcy, or simply the 'avoided pension cost':

$$APCost = (1 - p) \left(\frac{\mu}{2}\mathbb{E}(S^2|\bar{C}) - \mathbb{E}(\chi S|\bar{C}) - \mathbb{E}(S|\bar{C}) \right) \quad (\text{A.49})$$

Therefore, a firm that would over-invest under a risky agreement will choose a safe agreement when the cost of doing so – fully internalizing the pension cost when production fails – outweighs the benefit – avoiding the cost of over-investment.

A firm that under-contributes under a risky agreement If the cost to under-contributions is lower than the cost to over-investment, the sponsor knows that the ideal risky financing arrangement will imply it under-contributes to the pension. The firm chooses a safe agreement when the cost to under-contributing is greater than the pension cost avoided in bankruptcy:

$$UCcost > (1 - p) \left(\frac{\mu}{2}\mathbb{E}(S^2|\bar{C} - \Delta C) - \mathbb{E}(\chi S|\bar{C} - \Delta C) - \mathbb{E}(S|\bar{C} - \Delta C) \right)$$

A firm without a pension The previous section suggests that a firm without a pension will choose to constrain its borrowing so that it invests optimally. The results of this sug-

gestion suggest that a firm will make a safe agreement when the cost of under-contributing are higher than the avoided pension cost. When a firm does not sponsor a pension, both are zero. Therefore, a firm without a pension is indifferent between safe and risky financing. This is the canonical Modigliani-Miller result.

APPENDIX B

Model Solution With Corporate Tax

Now suppose assets held in the firm are subject to a corporate tax τ . Debt payments and pension contributions are both tax deductible, and returns earned on assets held in the pension account can be claimed as an exemption. If the pension is over 150 percent funded, contributions to and returns on the pension account are no longer tax deductible.

B.1 Bankruptcy constraints and 3rd period payoff

The firm remains solvent if it is able to repay the lender with after-tax corporate profits and the claimable amount in the pension account:

$$\begin{aligned}
 & \underbrace{(1 - \tau) [z^j f(I) + (1 + r)(B + X + \underline{E} - I - C)]}_{\text{After-tax assets held within the firm}} \\
 & + \underbrace{\chi^w [(1 + \rho^k)(P + C) - D]}_{\text{Pension assets that could be used to cover required payments}} \\
 & - \underbrace{\tau C \mathbb{1}\{(1 + \rho^k)(P + C) > 150D\}}_{\text{Loss of tax break over 150\% funded}} \geq \underbrace{b}_{\text{Required payment to lender}}
 \end{aligned} \tag{B.1}$$

Let T be the excise tax on assets taken out of the pension, F be the (proportional) cost associated with terminating a pension plan, and τ be the corporate tax rate. The claimable portion of pension assets is:

$$\chi = \begin{cases} 0 & \text{If pension is in deficit: } (1 + \rho^k)(P + C) < D \\ (1 - T - F) & \text{if } (1 + \rho^k)(P + C) \in (D, 1.5D) \\ (1 - T - F - \tau) & \text{if } (1 + \rho^k)(P + C) > 1.5D \end{cases} \tag{B.2}$$

Contributions to the pension account are tax deductible and returns earned on the assets held in the pension account can be claimed as tax exemptions. The loss of the tax break when the pension account is over 150 percent funded is captured in the regulatory cost of pension. The firm's third period payoff is:

$$V^{jk} = \begin{cases} \underbrace{(1 - \tau)[z^j f(I) + (1 + r)(B + X + \underline{E} - I - C) - b]}_{\text{Profits held in firm}} \\ + \underbrace{[(1 + \rho^k)(P + C) - D]}_{\text{Surplus or deficit in pension}} - \underbrace{\frac{\mu}{2} [(1 + \rho^k)(P + C) - D]^2}_{\text{Regulatory pension cost}} \\ \text{If the firm is solvent} \\ 0 \\ \text{If firm is insolvent} \end{cases} \quad (\text{B.3})$$

The lender's third period payoff is:

$$W^{jk} = \begin{cases} b \\ \text{If firm is solvent} \\ \underbrace{(1 - \tau)[z^j f(I) + (1 + r)(B + X + \underline{E} - I - C)]}_{\text{Profits held within firm}} + \\ \underbrace{\chi^w [(1 + \rho^k)(P + C) - D]}_{\text{Potential claimable pension assets}} \\ \text{If the firm is insolvent} \end{cases} \quad (\text{B.4})$$

B.2 The loan agreement

A safe agreement When the firm agrees to raise equity \bar{E} such that it will not face bankruptcy if production fails, the firm sets $b_S = (1 + r)B$

A risky agreement Suppose the firm agrees to raise equity $E < \bar{C}$, implying that the firm will go bankrupt if production fails. The lender correctly predicts the firm's allocation and sets:

$$b_R = (1 + r)B + \frac{1 - p}{p} \left\{ (1 - \tau) [(1 + r)(I - X - E) - z^F f(I) + (1 + r)C - \mathbb{E}(\chi S | C)] \right\} \quad (\text{B.5})$$

B.3 The Allocation Decisions

In the second period, after the firm raises Y , it allocates under a safe or risky agreement (depending on its period 1 financing decision):

A Safe Agreement	A Risky Agreement
<p>The sponsor chooses I_S^τ and C_S^τ to maximize:</p>	<p>The sponsor chooses I_R and C_R to maximize:</p>
$(1 - \tau) \left(\mathbb{E}(z) f(I^\tau) + (1 + r)(Y - I^\tau - C^\tau) - b_s \right) + \mathbb{E}(S C^\tau) - \frac{\mu}{2} \mathbb{E}(S^2 C^\tau)$	$(1 - \tau) p \left(z^S f(I) + (1 + r)(Y - I - C) - b_r \right) + \mathbb{E}(X C) - \frac{\mu}{2} \mathbb{E}(S^2 C)$
<p>subject to</p>	<p>subject to</p>
$Y \geq I_S^\tau + C_S^\tau \quad \text{multiplier: } \eta_S$	$Y \geq I + C \quad \text{multiplier: } \eta_R$
$Y = B + X + \underline{E}$	$Y = B + X$
$I_S^\tau \geq 0 \quad C_S^\tau \geq 0 \quad \text{multipliers: } \xi_I, \xi_C$	$I \geq 0 \quad C \geq 0 \quad \text{multipliers: } \xi_I, \xi_C$
<p>Solvency when production fails:</p>	<p>Bankruptcy when production fails:</p>
$g^F(I_S, C_S) \geq b_s$	$g^F(I, C) < b_r$
	<p>Solvency when production succeeds</p>
	$g^S(I, C) \geq b_r$

Notes: $\mathbb{E}(z) = pz^F + (1 - p)z^S$ is the expected productivity. The function $g^X(I, C)$ is the amount of funds the sponsor has on hand to pay expenses in period 3: $g^X(I, C) = (1 - \tau)(z^X f(I) + (1 + r)(Y - I - C)) + \chi^F [(1 + \rho^F)(P + C) - D] - \tau C \mathbb{1}\{(P + C)(1 + \rho^k) > 150D\}$

When the firm faces a safe agreement, the first-order conditions determining I and C are:

$$f'(I_S^\tau) = \frac{1 + r}{\mathbb{E}(z)} + \frac{\eta - \xi_I}{(1 - \tau)\mathbb{E}(z)} \tag{B.6}$$

$$\frac{\partial \mathbb{E}(S|C_S^\tau)}{\partial C} - \frac{\partial \mathbb{E}(S^2|C_S^\tau)}{\partial C} = (1 - \tau)(1 + r) + \eta - \xi_C$$

When the firm faces a risky agreement, the first-order conditions determining I and C

are:

$$f'(I_R^\tau) = \frac{1+r}{z^s} + \frac{\eta - \xi_I}{(1-\tau)pz^s} \quad (\text{B.7})$$

$$\frac{\partial \mathbb{E}(S|C_R^\tau)}{\partial C} - \frac{\partial \mathbb{E}(S^2|C_R^\tau)}{\partial C} = (1-\tau)(1+r) + \frac{\eta - \xi_C}{p}$$

As in the solution without taxes, the interior solutions to the above problems describe socially optimal investment, and the firm's optimal over-investment: $f'(I_S^*) = \frac{1+r}{\mathbb{E}(z)}$ and $f'(I_R^*) = \frac{1+r}{z^s}$. The available deduction for the return to assets held in the pension account encourages the firm to contribute make a higher optimal contribution:

$$\bar{C}^\tau = \frac{\mathbb{E}\{1 + \rho\} - (1-\tau)(1+r)}{\mu \mathbb{E}(1 + \rho)^2} + D \left(\frac{\mathbb{E}\{1 + \rho\}}{\mathbb{E}\{(1 + \rho)^2\}} \right) - P \quad (\text{B.8})$$

With taxes, a levered firm that over-invests sets $(I, C) = (I_R^*, \bar{C}^\tau)$. Under a safe agreement, the firm sets $(I, C) = (I_S^*, \bar{C}^\tau)$

B.4 Financing

B.4.1 Expected firm payoffs under safe and risky financing

The value to a firm of raising debt B and equity E under a risky agreement is:

$$V^R = (1-\tau) \left(pz^S f(I) + p(1+r)(B + X + E - I - C) - pb^R(B, E) \right) + p \left(\mathbb{E}(S|C) - \frac{\mu}{2} \mathbb{E}(S^2|C) \right) - (1-\tau^E)(1+r^o)E$$

Where τ^E is the income tax rate the shareholder faces. Substituting equation B.5 for $b^R(B, E)$,¹ the firm value is:

$$V^R = (1-\tau) \left(\mathbb{E}(z)(I) + (1+r)(X - I - C) \right) + p \left(\mathbb{E}(S|C) - \frac{\mu}{2} \mathbb{E}(S^2|C) \right) + (1-p) \mathbb{E}(\chi S|C) + E \left((1-\tau)(1+r) - (1-\tau^E)(1+r^o) \right) \quad (\text{B.9})$$

If the tax rate facing the shareholder is lower than the tax rate facing the firm, equity is more costly than debt.

¹Noting that full information implies that the lender will adjust the borrowing rate according to actual firm decisions.

The value to a firm of raising debt B and equity E under a safe agreement is:

$$V^S = (1 - \tau) \left(\mathbb{E}(z)f(I) + (1 + r)(B + X + E - I - C) - b^S(B, E) \right) + \left(\mathbb{E}(S|C) - \frac{\mu}{2} \mathbb{E}(S^2|C) \right) - (1 - \tau^E)(1 + r^o)E$$

Substituting the safe rate for borrowing:

$$V^S = (1 - \tau) \left(\mathbb{E}(z)f(I) + (1 + r)(X - I - C) \right) + \left(\mathbb{E}(S|C) - \frac{\mu}{2} \mathbb{E}(S^2|C) \right) + E \left((1 - \tau)(1 + r) - (1 - \tau^E)(1 + r^o) \right) \quad (\text{B.10})$$

Again, equity is costly, but the firm internalizes pension gains and costs regardless of whether production fails or succeeds.

B.4.2 Firm's financing optimization

A Safe Agreement	A Risky Agreement
$(B_S, E_S) = \arg \max_{B, E} V^S(B, E)$	$(B_R, E_R) = \arg \max_{B, E} V^R(B, E)$
$s.t. : I(B, E) + C(B, E) \leq X + B + E$	$s.t. : I(B, E) + C(B, E) \leq X + B + E$
$B \geq 0 \quad \bar{E} \geq E \geq 0 \quad I \geq 0$	$B \geq 0 \quad \bar{E} \geq E \geq 0 \quad I \geq 0$
<p>Where \bar{E} is the level of equity required to ensure solvency when the firm makes risky over-investment</p>	<p>Where \bar{E} is the level of equity required to ensure solvency when the firm makes risky over-investment</p>

Risky agreement Let ϕ be the multiplier on $I(B, E) + C(B, E) \leq X + B + E$ and ξ_x be the multiplier with respect to variable x . The first-order conditions for debt and equity:

$$\xi_B = -\phi \left(1 - \left(\frac{\partial I}{\partial B} + \frac{\partial C}{\partial B} \right) \right) - \frac{\partial I}{\partial C} \underbrace{\left((1 - \tau) \mathbb{E}(z)f'(I) - (1 + r) + \xi_I \right)}_A - \frac{\partial C}{\partial B} \underbrace{\left((1 - p) \frac{\partial \mathbb{E}(S|C)}{\partial C} + p \left(\frac{\partial \mathbb{E}(S|C)}{\partial C} - \frac{\mu}{2} \frac{\partial \mathbb{E}(S^2|C)}{\partial C} \right) - (1 - \tau)(1 + r) + \xi_C \right)}_B$$

$$\begin{aligned}
\xi_E - \bar{\xi}_E = & \\
& (1 - \tau^E)(1 + r^o) - (1 - \tau)(1 + r) - \phi \left(1 - \left(\frac{\partial I}{\partial B} + \frac{\partial C}{\partial B} \right) \right) \\
& - \frac{\partial I}{\partial C} \underbrace{\left((1 - \tau)(\mathbb{E}(z)f'(I) - (1 + r) + \xi_I) \right)}_A \\
& - \frac{\partial C}{\partial B} \underbrace{\left((1 - p) \frac{\partial \mathbb{E}(S|C)}{\partial C} + p \left(\frac{\partial \mathbb{E}(S|C)}{\partial C} - \frac{\mu}{2} \frac{\partial \mathbb{E}(S^2|C)}{\partial C} \right) - (1 - \tau)(1 + r) + \xi_C \right)}_B
\end{aligned}$$

From the firm's second period optimization problem, we have:

$$\frac{\partial I_{RC}^\tau}{\partial B} = \begin{cases} 0 & \text{if } \phi = 0 \\ \frac{\bar{C}^\tau - \mu \mathbb{E}\{(1+\rho)^2\} \frac{\partial \xi_C}{\partial B}}{p(1-\tau)f''(I_{RC}^\tau) - \mu \mathbb{E}\{(1+\rho)^2\}} & \text{if } \phi > 0 \end{cases} \quad (\text{B.11})$$

$$\frac{\partial C_{RC}^\tau}{\partial B} = \begin{cases} 0 & \text{if } \phi = 0 \\ \frac{p(1-\tau)f''(I_{RC}^\tau) - C^\tau - \frac{\partial \xi_C}{\partial B}}{p(1-\tau)f''(I_{RC}^\tau) - \mu \mathbb{E}\{(1+\rho)^2\}} & \text{if } \phi > 0 \end{cases} \quad (\text{B.12})$$

Therefore, if the firm borrows enough to save in the safe asset, $\eta = 0$ and

$$\xi_E - \bar{\xi}_E = (1 - \tau^E)(1 + r^o) - (1 - \tau)(1 + r) \quad (\text{B.13})$$

$$\xi_B = 0 \quad (\text{B.14})$$

The firm borrows $B > 0$. If $(1 - \tau^E)(1 + r^o) > (1 - \tau)(1 + r)$, $\xi_E > 0$ and the firm does not raise equity, $E = 0$. Note that, if $\phi > 0$, $\frac{\partial C_{RC}^\tau}{\partial B} + \frac{\partial I_{RC}^\tau}{\partial B} = 1$, $\frac{\partial C_{RC}^\tau}{\partial B} = \frac{\partial C_{RC}^\tau}{\partial E}$, and $\frac{\partial I_{RC}^\tau}{\partial B} = \frac{\partial I_{RC}^\tau}{\partial E}$. Therefore, when the firm does not raise enough funds to save in the safe asset, the first order conditions reduce to:

$$\xi_B = - \left(\frac{\partial I_{RC}^\tau}{\partial B} A + \frac{\partial C_{RC}^\tau}{\partial B} B \right) \quad (\text{B.15})$$

$$\xi_E = (1 - \tau^E)(1 + r^o) - (1 - \tau)(1 + r) - \left(\frac{\partial I_{RC}^\tau}{\partial E} A + \frac{\partial C_{RC}^\tau}{\partial E} B \right) \quad (\text{B.16})$$

This is a solution iff:

$$\left(\frac{\partial I_{RC}^\tau}{\partial B} A + \frac{\partial C_{RC}^\tau}{\partial B} B \right) \leq 0 \quad (\text{B.17})$$

One solution exists where $A = B = 0$. In this case, the firm sets investment at the social optimum I_S^* , and contributions:

$$\bar{C}^\tau - \Delta C^\tau = \bar{C}^\tau - \frac{(1+r)(1-\tau)p(1-p)(z^s - z^F)}{\mathbb{E}(z)\mu\mathbb{E}\{(1+\rho)^2\}} \quad (\text{B.18})$$

When the return on pension assets can be claimed as an exemption, the firm will contribute more to its pension when it borrows endogenously but constrains its funds raised by: $\tau\Delta C$

Choosing financing position As in the case without taxes, a levered firm chooses to borrow substantially and over invest if $V_R(I_R^*, \bar{C}^\tau) > V_R(I_S^*, \bar{C}^\tau - \Delta C^\tau)$. This occurs when:

$$\begin{aligned} & (1-\tau) \left\{ \underbrace{\left(\mathbb{E}(z)f(I_S^*) - (1+r)I_S^* \right) - \left(\mathbb{E}(z)f(I_R^*) - (1+r)I_R^* \right)}_{OICost(I_R^*)} \right\} > \\ & - \left(p(\mathbb{E}(S|\bar{C}^\tau - \Delta C^\tau) - \mathbb{E}(S|\bar{C}^\tau)) - p\frac{\mu}{2}(\mathbb{E}(S^2|\bar{C}^\tau - \Delta C^\tau) - \mathbb{E}(S^2|\bar{C}^\tau)) \right. \\ & \left. + (1-p)(\mathbb{E}(\chi S|\bar{C}^\tau - \Delta C^\tau)) - (1-\tau)(1+r)\Delta C^\tau \right) \\ & \underbrace{\hspace{10em}}_{UCCost^\tau(\bar{C}^\tau - \Delta C^\tau) + \tau\Delta C^\tau} \\ & (1-\tau)OICost(I_R^*) < UCCost^\tau(\bar{C}^\tau - \Delta C^\tau) + \tau\Delta C^\tau \quad (\text{B.19}) \end{aligned}$$

A higher corporate tax makes it more likely for a levered firm to borrow more and, as a result, over-invest in risky production. A firm will choose the levered position that involves investment risk when $V^R(I_R^*, \bar{C}^\tau) > V^S(I_S^*, \bar{C}^\tau)$, or:

$$\begin{aligned} & (1-\tau) \left\{ \underbrace{\left(\mathbb{E}(z)f(I_S^*) - (1+r)I_S^* \right) - \left(\mathbb{E}(z)f(I_R^*) - (1+r)I_R^* \right)}_{OICost(I_R^*)} \right\} > \\ & \underbrace{(1-p)\left(\frac{\mu}{2}\mathbb{E}(S^2|\bar{C}^\tau) - \mathbb{E}(S|\bar{C}^\tau) + \mathbb{E}(\chi S|\bar{C}^\tau)\right)}_{APCost(\bar{C}^\tau)} + \underbrace{\bar{E}^S((1+r^o)(1-\tau^E) - (1+r)(1-\tau))}_{MECost(\bar{E}^S)} \\ & \hspace{15em} (\text{B.20}) \end{aligned}$$

Here, $MECost(\bar{E}^S)$ is the cost of the minimum amount of equity the firm must raise to avoid bankruptcy – or minimize the moral hazard problem. A higher corporate tax will encourage the firm to choose a safe financing position because it decreases the payoff the

firm can get from making a safe investment choice (decreasing the LHS). On the other hand, since a firm must raise costly equity, a higher corporate tax would encourage the firm to take on a levered position. Similarly, a firm that chooses to under-contribute will do so when:

$$APCost(\bar{C}^\tau) + \bar{E}^S(1 - \tau^L)(1 + r^o) < UCCost(\bar{C}^\tau - \Delta\bar{C}^\tau) + \tau(1 + r)\Delta C^\tau \quad (\text{B.21})$$

Again, a firm that does not face bankruptcy will raise costly equity, decreasing the attractiveness of a safe agreement. A firm that faces bankruptcy but under-contributes will pay the cost associated with under-contributing – which is higher when taxes are higher due to the tax break on returns. Therefore, higher taxes encourage a firm to raise more debt and make riskier investment decisions (choosing the unconstrained borrowing amount rather than the constrained borrowing amount).

APPENDIX C

Firms Contributing Minimum Before and During Recession

Firms that contribute at the minimum required contribution during the credit crunch are larger, with larger pension obligations relative to their counterparts that do not contribute at the minimum required contribution, than firms contributing at the minimum required contribution in the early 2000s. To explore the role of this particular sample selection in driving the estimates in Tables 3 and 4, this appendix considers two groups of firms. The “pre-credit crunch” sample includes those firms that contributed at or below the minimum required contribution in some year before 2009. The “credit crunch” sample includes those firms that contributed at or below the minimum at some point during the credit crunch.

Figure 3.4 shows the fraction of firms in the pre-credit crunch sample that contribute at or above the minimum required contribution from 2000 through 2013. Firms contributing at or below the minimum at some point before the recession were almost as likely to contribute at or below the minimum during the recession: over 15 percent percent of the firms in this sample contributed at the minimum required contribution from 2009 through 2012. This pre-credit crunch group can shed light on differences in leverage and ratings among firms that frequently contribute only the minimum required, separating out those firms that were driven to the minimum by asset price declines in the recession. Figure 3.7 describes the fraction of firms in the credit crunch sample that contributed at or below the minimum from 2000 through 2013. Unlike the pre-credit crunch sample, firms contributing at the minimum during the credit crunch were substantially less likely to do so prior to the recession. This sample maximizes the difference in the ratings and leverage differences between firms at the minimum and over the minimum before and after the recession due to a change in the mix of firms contributing at the minimum during the credit crunch.

Figures 3.5 and 3.8 describe the average long-term debt ratio and S&P ratings index for firms contributing at and above the minimum for these two groups. Both groups show patterns similar to the aggregate pattern: in the early 2000s, firms contributing at the min-

imum borrowed more and had lower ratings; these differences narrowed during the recession. Tables C.1 and C.2 show the results from running main empirical specification on each sample. In the pre-credit crunch sample, firms contributing at the minimum borrow 4 percentage points more than firms contributing above the minimum from 2000 through 2007. Their ratings are insignificantly lower prior to the credit crunch, but approximately three-quarters notch higher during the credit crunch. This pattern is particularly strong among firms contributing at the minimum required contribution during the recession. This suggests that a lot of the pre- and post-credit crunch differences are due to changes in the mix of firms contributing at and below the minimum during the recession.

Table C.1: Difference in Leverage and Ratings for Firms at and above Minimum: Pre-credit crunch sample

	Debt to non-pension assets			Ratings Index		
	(1)	(2)	(3)	(4)	(5)	(6)
MRC (α)	.0421*** (.0161)	.0362** (.0165)	.041** (.0163)	-.0195* (.011)	.00217 (.00772)	-.00486 (.00774)
MRC \times Credit Crunch (β)	-.0357 (.0412)	-.0344 (.0421)	-.0548 (.0372)	.0458* (.0252)	.00717 (.0215)	.0344* (.0196)
$\alpha + \beta$.0264 (.0870)	.0093 (.0513)	.0295 (.0531)	.0064 (.1204)	.0017 (.1169)	-.0138 (.1039)
Industry and Year Fixed Effects	X	X	X	X	X	X
Pension Controls		X	X		X	X
Firm Controls			X			X
Observations	1922	1870	1610	1082	1058	1055
R^2	0.063	0.064	0.169	0.065	0.420	0.592

Standard errors, clustered at firm level, in parentheses; * $p < .10$, ** $p < .05$, *** $p < .01$. All specifications include year and industry fixed effects. *MRC in previous year* is an indicator of whether the firm contributed at the minimum to any of its pension plans in the previous year. *Credit Crunch* is an indicator for the years 2009, 2010, and 2011. Firm size is measured by the log of sales, Tangibility is measured as the ratio of PPE to total assets, Profitability is measured as the ratio of cash to total assets. Controls also include Altman's z-score (a measure of financial distress), median industry leverage, and an indicator for negative owner equity. The hypotheses are $\alpha > 0$ and $\alpha + \beta = 0$. $\alpha > 0$ implies firms contributing at the MRC borrow more than firms in the same industry contributing above the MRC in years in which financing is easy. $\alpha + \beta_1 \alpha$ implies that firms contributing at the MRC do not borrow as much more other firms in the industry not contributing at the MRC when financing is tight.

Table C.2: Difference in Leverage and Ratings for Firms at and above the Minimum: Credit crunch sample

	Debt to non-pension assets			Ratings Index		
	(1)	(2)	(3)	(4)	(5)	(6)
MRC (α)	.0745*** (.0254)	.0864*** (.0272)	.063** (.0256)	-.0719*** (.0209)	-.0614*** (.0191)	-.0417** (.0197)
MRC \times Credit Crunch (β)	-.0794*** (.0277)	-.0905*** (.0318)	-.0572** (.0287)	.0622** (.024)	.0398* (.0227)	.0304 (.021)
$\alpha + \beta$	-.0097 (.0530)	-.0216 (.0559)	-.0113 (.0468)	-.0049 (.0457)	-.0041 (.0489)	.0058 (.0477)
Industry and Year Fixed Effects	X	X	X	X	X	X
Pension Controls		X	X		X	X
Firm Controls			X			X
Observations	2283	2149	1952	1507	1411	1398
R^2	0.047	0.048	0.151	0.068	0.324	0.512

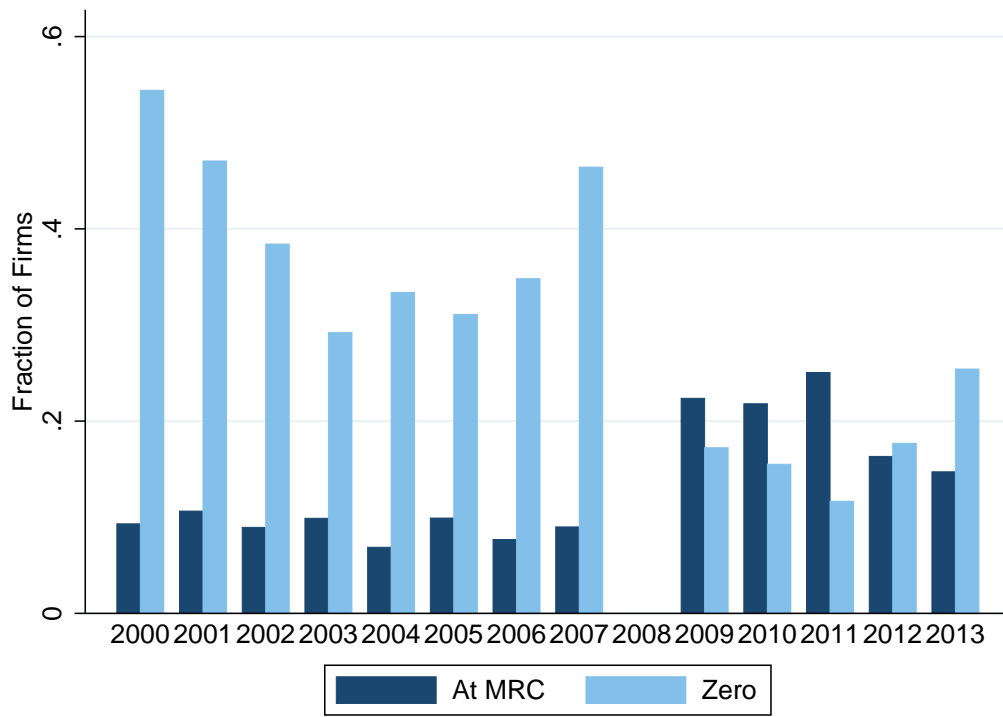
Standard errors, clustered at firm level, in parentheses; * $p < .10$, ** $p < .05$, *** $p < .01$. All specifications include year and industry fixed effects. *MRC in previous year* is an indicator of whether the firm contributed at the minimum to any of its pension plans in the previous year. *Credit Crunch* is an indicator for the years 2009, 2010, and 2011. Firm size is measured by the log of sales, Tangibility is measured as the ratio of PPE to total assets, Profitability is measured as the ratio of cash to total assets. Controls also include Altman's z-score (a measure of financial distress), median industry leverage, and an indicator for negative owner equity. The hypotheses are $\alpha > 0$ and $\alpha + \beta = 0$. $\alpha > 0$ implies firms contributing at the MRC borrow more than firms in the same industry contributing above the MRC in years in which financing is easy. $\alpha + \beta_1\alpha$ implies that firms contributing at the MRC do not borrow as much more other firms in the industry not contributing at the MRC when financing is tight.

APPENDIX D

Firms Contributing Nothing

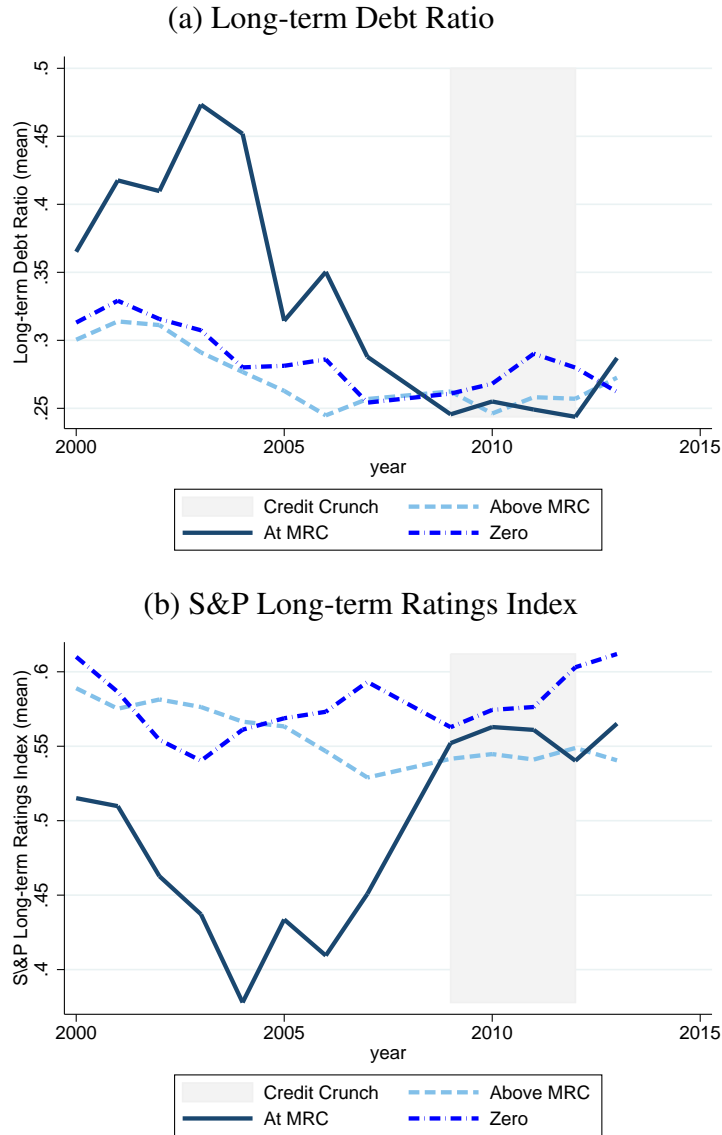
Firms that contribute zero to their pension account are at a corner solution like firms contributing at the minimum required contribution: they may prefer to take money out of their pension but are legally prohibited from doing so. These firms do not, however, face an incentive to borrow to make minimum contributions when the cost of borrowing is low. Therefore, the main analysis considers firms contributing zero in hand with firms contributing above the minimum required contribution. Figure D.1 shows the fraction of firm contributing at the minimum required and the fraction of firms contributing zero. Between 30 and 60 percent of firms contribute nothing from 2000 through 2007; this percentage is higher in years, like 2000 and 2007, in which high asset returns have increased the value of pension assets. The fraction of firms contributing nothing drops precipitously during the credit crunch. In 2011, for example, on 6 percent of firms contributed zero. Figure D.2 shows that firms contributing zero display debt and ratings patterns similar to those firms that contribute above the minimum required contribution.

Figure D.1: Firms Contributing at Minimum Required Contribution or Nothing



Notes. Shows the percent of firms that contribute at or below the minimum required contribution to at least one pension plan reported on the Form 5500 and matched to its sponsor in Compustat. Plans are categorized as contributing at or below the minimum required contribution if total employer contributions for the given year, reported in schedule B of the Form 5500, are less than or equal to the minimum required contribution reported on that same schedule. The Department of Labor changed reporting forms in 2008; the first year of the new reporting forms is not available in the online release Form 5500.

Figure D.2: Debt and Ratings of Firms Contributing at and above the Minimum: Credit crunch sample



Notes. The dotted line includes firms making zero contribution to their pension, while the solid line includes firms contributing below the minimum required contribution. Constrained firms are those that contributed at the minimum required contribution in the previous year. Unconstrained firms are those that contributed above the minimum required contribution in the previous year. Data on both variables plotted – debt to non-pension assets and the S&P long-term bond rating – is from Compustat. The long-term bond rating is transformed into a continuous index: a rating of AAA translates to 1 while a rating of D translates to 0. Each notch improvement in bond rating, such as an increase from B to B+, increases the index by .045. An index of .6 is equivalent to a bond rating of BBB-. The lines plot the average within year and contribution group.

APPENDIX E

Data Appendix

Collateral: The ratio of tangible assets to total assets. Compustat variable *ppent* over Non-Pension Assets.

Consolidated Assets: The sum of Non-Pension Assets and Pension Assets.

Consolidated Debt: The sum of External Debt and Pension Debt

Consolidated Leverage: The ratio of consolidated debt to consolidated assets, where consolidated debt is the sum of non-pension assets and pension assets and consolidated debt is the sum of external and pension debt.

Contributions: (Table 4, Form 5500) Employer contributions reported on schedule SB

DB: An indicator equal to 1 if the Compustat firm reports pension obligations in the given year.

External Debt: The sum of current liabilities and long-term debt: Compustat variables $dltt + dlc$

External Leverage: The sum of current liabilities and long-term debt, Compustat variables $dltt + dlc$, over non-pension assets

Firm Age: Number of years since firm entered the Compustat sample

Firm Size: Log of total sales, Compustat variable *sale*

Funding Ratio: (The ratio of the market value of assets at the beginning of the year to the actuarial liability, both reported on Form 5500 Schedule SB)

Interest Coverage Ratio: The ratio of operating income after depreciation and interest payments to interest payments. The sum of Compustat variables *oiadp* and *xint* over *xint*.

Investment Grade: An indicator equal to one if the firm's long-term S&P bond rating, Compustat variable *splticrm*, is investment grade or higher (above BBB-).

Loan Amount: Amount of loan, in \$ millions. Deal Scan variable *loanamount*.

Loan Maturity: The number of months between issuance and maturity of the loan, Deal Scan.

Long-term: An indicator equal to 1 if facility is classified as a term loan or long-term bond according to Deal Scan.

Market-to-Book: The ratio of the firm's market value to book value. Market value is Compustat variables ($prcc_f * cshpri + at - ceq$) and book value of assets is *at*.

Oeneg: An indicator equal to 1 if the owner's equity, Compustat variable *seq* is less than zero.

Non-Pension Assets: The book value of assets (Compustat variable *at*) less pension assets reported in the balance sheet (Compustat variable *pcppao*), and cleansed of income adjustments to book assets.

Participants: Sum of active and retired participants reported on the Form 5500.

Pension Assets: Total pension assets reported on the 10-k, the sum of Compustat variables *pplao* and *pplau*

Pension Deficit: Pension assets reported at the beginning of the year less the current liability reported on Schedule SB/B

Pension Leverage: Total pension assets reported on the 10-k, the sum of Compustat vari-

ables *pplao* and *pplau*, over non-pension assets.

Pension Obligations: The projected benefits obligation reported on a DB sponsor's balance sheet. The sum of Compustat variables *pbpro* and *pbpru*

Profitability: The ratio of operating income before depreciation (Compustat variable *oibdp*) to Non-Pension Assets.

Ratings Index: A index from 0 to 1 created from the S&P long-term bond rating, Compustat variable *splticrm*. A rating of AAA registers as 1, a rating of D (default) registers as 0. Each notch increase in rating (eg., from A to A+) increases the index by $.04\bar{5}$

Rated: An categorical variable equal to one if the firm's long-term S&P bond rating, Compustat variable *splticrm*, is available, equal to 2 if the firm's long-term S&P bond rating is investment grade or higher (above BBB-), and zero otherwise.

Short-term: An indicator equal to 1 if facility is classified as a short-term loan or equity line of credit.

Secured: An indicator equal to 1 if the loan is classified as secured in Deal Scan.

Spread: All-in spread on the drawn portion of the facility, Deal Scan variable *allindrawn*.

Tangibility: The ratio of tangible assets to total assets. Compustat variable *ppent* over Non-Pension Assets.

Total Leverage: The sum of pension and external leverage.

Zscore: Altman's Z-score, measure of closeness to bankruptcy, calculated as a linear combination of the Compustat variables: $3.3 * ebit + sale + 1.4 * re + 1.2 * ((act - dlc)/at)$

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