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Investment and Financing Constraints: Evidence from the Funding of Corporate Pension Plans

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Abstract

I exploit a discontinuity in funding rules for defined benefit pension plans in order to identify the importance of financing constraints for corporate investment. Firms are required to make contributions to underfunded pension plans but are limited in their ability to contribute to overfunded plans. I construct simulated levels of mandatory contributions from the pension tax filings of a large sample of firms that sponsor defined benefit pension plans, and I examine the relationship between corporate capital expenditures and mandatory contributions within firms over time. In a regression context, capital expenditures display a strong negative correlation with mandatory contributions, even when controlling for the funding status itself. The magnitude of the investment response is inversely related to the quality of a firm's credit rating, and it is higher for firms that appear to face financing constraints based on other observable margins. I find sensitivities of a similar magnitude using mandatory contributions as an instrument for endogenous components of cash flow in a two-stage panel setting. I also present evidence suggesting that firms which do not sponsor defined benefit pension plans may undertake some of the capital investment that pension sponsors in their industry are unable to take up when required contributions are high.

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1. Introduction

"Companies cannot commit to building new plants, launching new research projects or hiring new employees if that cash is needed to fund pensions."

—Glen A. Barton, Chairman and Chief Executive of Caterpillar Inc. (New York Times, 22 June 2003)

Firms that sponsor defined benefit (DB) pension plans must make financial contributions to their pension funds according to legally specified formulas. These contributions have a direct impact on a company's internal financial resources. If a firm is financially constrained, contribution requirements may also affect its ability to invest in new capital, conduct research and development, and make acquisitions. To the extent that required contributions can be separated from the firm's investment opportunities, they are potentially useful instruments in identifying the response of corporate capital expenditures to changes in internal financial resources. In this paper I exploit a discontinuity in the funding rules for US pension plans in order to measure this response. Firms with underfunded pension plans are required by law to make contributions determined by nonlinear functions of the funding status.[1] Firms with overfunded plans may choose to make contributions but only up to certain full funding limits beyond which contributions are not tax-deductible.[2]

The crisis in pension funding precipitated by stock market declines and falling interest rates in 2000-2002 highlights the importance of this issue. Exchange listed US firms with DB pension plans had approximately $1.6 trillion of aggregate pension assets and $2.1 trillion of discounted projected liabilities at the end of 2002, representing a cumulative underfunding of $440 billion or 21.1% on a projected benefit basis.[3] This underfunding follows a 2.1% underfunding in 2001, the first aggregate deficit since 1995. The years 1999 and 2000 experienced 35.4% and 22.4% overfunding respectively. The Pension Benefit Guaranty Corporation estimates that US corporations in 2003 will have to make $65.5 billion of contributions, compared to $6.4 billion in 2000. Without legislative relief this figure will rise to $125.3 billion in 2004.[4] Exchange listed US firms with DB pension plans had approximately $608 billion in aggregate net income and $619 billion in aggregate capital expenditures in 2002,

[1] A plan is "underfunded" when the value of plan assets falls below the plan's current liability as defined by the applicable law.

[2] Until 2002, contributions above the full funding limitation were subject to a 10% excise tax.

[3] The Compustat industrial company file contains data from SEC 10-K annual company filings on the total pension assets and projected benefit obligation (PBO) for all companies with defined benefit (DB) pension plans. These figures are based on aggregation of the Compustat universe within years.

[4] With the measures currently under consideration by Congress, this figure would fall to $103.5 billion. See Pension Benefit Guaranty Corporation (2003), "Senate Panel Votes to Give Pension Relief to Companies", *New York Times* (September 16, 2003), and "House Backs Cut in Pension Outlays Over Two Years", *Wall Street Journal* (October 9, 2003).

so these contributions would represent a substantial drain on corporate cash. To the extent that the cost of financing capital expenditures out of internal resources is smaller than the cost of raising external equity or debt finance, the need to fund pensions may critically raise the cost of capital for corporations that sponsor DB plans.

This paper investigates the response of corporate expenditures — primarily on capital but also on R&D, acquisitions, and other cash uses — to variation in required pension contributions. I use the discontinuity in pension funding requirements around the level of full funding in order to identify an effect of required contributions that is purged of potential correlations with investment opportunities. The results may therefore be interpreted as estimates of the response of corporate investment to internal financial resources when the investment opportunity set is held constant. If there are no differential costs of internal and external finance, the model of Modigliani and Miller (1958) predicts that the requirement of making contributions to underfunded plans should not affect expenditure decisions. The firm undertakes all projects with positive net present value calculated using its cost of capital and rejects all projects with negative net present value. However, if firms are financially constrained — if external finance is more expensive than internal finance due to information asymmetries, agency costs, or incomplete contracting — capital expenditures should be negatively related to the extent of pension underfunding and to required contributions to underfunded plans.

This work is the first to estimate the response of capital expenditures to internal financial resources using instruments for internal cash in a large sample, panel setting. Much of the previous literature on financial constraints has focused on interpretations of the positive correlation between investment and cash flow. Fazzari, Hubbard and Petersen (1988) construe variation in investment-cash flow sensitivities across firms with different dividend payout ratios as evidence of differential financing constraints. Subsequent studies challenge their conclusions on both theoretical and empirical grounds, notably Kaplan and Zingales (1997), Erickson and Whited (2000), and Alti (2003). Blanchard, Lopez-de-Silanes, and Shleifer (1994) and Lamont (1997) move away from investment-cash flow sensitivities by observing the response to cash windfalls and shocks in very small, specialized groups of firms. In this paper, I take a formal approach to estimating the effect of cash hits on investment. I argue that with appropriate controls, mandatory pension contributions may be used as an instrument for internal cash and thus can be used to measure investment responses to internal resources in a broad sample.

I simulate mandatory contributions for an unbalanced panel of over 1,500 firms that sponsor DB pension plans during the period for which plan-level pension data is available. I then examine the relationship between corporate capital expenditures and mandatory contributions

within firms over time in the context of a simple investment model in which both cash flow and Tobin's Q may be related to investment opportunities. Estimating the effect of required pension contributions on investment while controlling for the pension funding status itself constitutes a powerful identification method, as mandatory contributions are a discontinuous function of the underlying pension funding status. Investment opportunities may be correlated with smooth functions of pension funding levels, but it is not reasonable to believe that they jump in the same arbitrary way as required contributions. This technique allows the financing constraints theory to be distinguished from a variety of alternative endogeneity hypotheses.[5]

In this context, I find a strong and significant negative response of capital expenditures to required contributions, with point estimates on the order of a $0.60 decrease in capital expenditures per dollar of mandatory contributions. I interpret this result as evidence of financing constraints of a larger magnitude and on a larger scale than previously recognized. I show that the size of the investment response is inversely related to the quality of a firm's credit rating, and it is higher for firms that appear to face financing constraints based on other observable margins. I also recast the empirical specification in an instrumental variables (IV) framework, using mandatory contributions as an instrument for endogenous components of cash flow. I derive answers of a similar magnitude, and the results are again robust to controlling for the funding status itself. The identification is helped by the fact that firms may have both overfunded and underfunded plans, since contemporaneous internal resources are altered only by underfunded plans. In an alternative specification, the extent of underfunding is used as an instrument that shifts cash flow through its effect on contributions, while the extent of overfunding is used as a control. All of these specifications yield broadly the same results.

An important general equilibrium consideration is whether firms that do not sponsor DB plans undertake some of the projects forgone by constrained pension sponsors. Policy implications may be different if the effects are largely distributional rather than reducing investment on a macroeconomic scale. I find that the investment of firms which do not sponsor DB plans rises with the contribution requirement for DB pension firms in their industry. The fact that non-pension firms undertake some of the investment projects that constrained pension firms leave on the table reduces the total decline in investment by approximately 12%.

This paper proceeds as follows. Section 2 discusses the institutional details of pension funding requirements and provides some theoretical motivations. Section 3 discusses the data, which come from Compustat and from the IRS 5500 filings. Section 4 presents the empirical

[5] In the labor economics literature, this identification strategy is known as a regression discontinuity (RD) technique. See van der Klauuw (1996), Angrist and Lavy (1999), and Angrist and Krueger (1999).

specifications and the results. Section 5 interprets the results in the context of some dynamic models and addresses intertemporal and general equilibrium considerations. Section 6 concludes and offers suggestions for further work.

2. Funding Requirements and Investment

In section 2.1, I present the institutional details of pension funding requirements. In section 2.2, the empirical specification is motivated with a simple two-period model of investment in which there is a random shock from pension contributions. Section 2.3 develops the primary empirical specification.

2.1. Funding Requirements

Despite a shift from defined benefit to defined contribution pension plans in the US over the past two decades, defined benefit plans remain a significant source of risk for corporate pension sponsors. Attention has recently been drawn to this issue by large unfunded pension liabilities at US firms such as General Motors, United Airlines, and many others. Figure 1 presents the distribution of the beginning-of-year funding status for Compustat firms from 1991-2003. The funding status is defined as pension assets minus pension liabilities divided by pension liabilities.[6] The figure shows that both the mean and median firms were underfunded as of the beginning of 2003 for the first time in the history of these series. Approximately 25% of firms were more than 25% underfunded on this basis. As of the beginning of 2002, the distribution of the pension status was broadly similar to its distribution in 1995, after the poor performance in 1994 of both equity and bond markets and before the equity market boom of the late 1990s. As recently as the beginning of 2000, 90% of firms were overfunded and the median firm was 40% overfunded. On the asset side, these swings were largely wrought by shifts in equity markets, which affect the value of pension assets invested in stocks. Declining interest rates have implied lower discount rates which have raised calculated pension liabilities.[7]

In general, firms with underfunded plans must contribute new benefits accrued during the fiscal year, plus some fraction of the funding shortfall. Firms with overfunded plans are not required to make contributions. Furthermore, maximum deductibility laws have limited the extent to which firms with overfunded plans can make voluntary contributions to buffer

[6] In Figure 1, pension liabilities are on a projected benefit obligation (PBO) basis, meaning that future salary increases of current plan participants are included in the estimated pension liability. This is the standard statement of pension liabilities in corporate financial statements, but is not the critical measure used to determine required pension contributions.

[7] The effect of falling interest rates on pension liabilities would have been offset by rising values of fixed income securities held in pension funds if bonds had been held in larger proportions. For one view of the broad shift towards equity investment in DB pension funds in the late 1990s, see Bergstresser, Desai, and Rauh (2003).

themselves against future shortfalls. The effects these mandatory contributions might have on firms' internal financial resources become more important for the investment of financially constrained firms as the funding status of corporate pensions deteriorates.

During the time period in this study, firms were required to contribute the larger of two calculated components: the *minimum funding contribution* and the *deficit reduction contribution*. Minimum funding contributions were first instituted by the Employee Retirement Income Security Act of 1974 (ERISA) and codified for tax qualified plans in §412(b)(1) of the Internal Revenue Code (IRC). The ERISA minimum funding requirements specify that sponsors of underfunded plans must contribute annually an amount equal to the present value of pension benefits accrued during the year, as well as installment payments on any unfunded liabilities. The annual pension benefit accrual is called the "normal cost" and is affected by the firm's choice of accounting methods.[8] The unfunded liability for ERISA purposes is the part of the projected benefit liability that is neither covered by plan assets nor is scheduled to be covered by future normal cost contributions. The unfunded liability may be amortized over a long period, typically five to 30 years.[9,10] The ability that ERISA gave firms to spread repayments of unfunded liabilities over very long time periods was generally believed to have contributed to inadequate funding of corporate plans.

The Pension Protection Act of 1987 changed the laws to require better funding of single-employer plans. The primary feature of this act was a rule that required between 13.75% and 30% of any underfunding to be deposited into the plan as deficit reduction contributions, also commonly known as "catch-up" contributions. The larger the funding deficit, the larger the percentage of the deficit that would have to be contributed. The remainder of the shortfall would be then be amortized over a period of three to five years. The percentage of the underfunding that must be contributed as a deficit reduction contribution in the first year under the 1987 law is equal to $min\{0.30,[0.30 - 0.25*(funding\ status - 0.35)]\}$, where the funding status is on an accumulated benefit obligation (ABO) basis.[11] Therefore, the minimum deficit reduction

[8] Firms may choose between a projected unit credit cost method or an entry age cost method. See Langbein and Wolk (2000), p. 362.

[9] Munnell and Soto (2003) provide an example. Suppose a plan's assets exceed its liabilities by $5m and the normal cost is $11m. The $5m deficit may be paid off over a period of 10 years. The minimum funding contribution in the first year then amounts to $11m + ($5m / 10) = $11.5m.

[10] ERISA also requires employees to contribute the amortization of past service costs, which arises when employers increase the benefit formula in a way that applies retroactively to employee service already provided. See Langbein and Wolk (2000), p. 364.

[11] The ABO at time *t* is the accrued liability, *i.e.* the present discounted value of all benefits that have been accrued by workers as of time *t*, without taking their future salary increases into account.

contribution percentage under this law is 13.75% for a funding status just under 100%, and the maximum is 30% for funding statuses below 35%.

The Retirement Protection Act (RPA) of 1994 changed funding requirements by exempting plans which are more than 90% funded (i.e. less than 10% underfunded) from deficit reduction contributions, as well as certain plans that are between 80% and 90% funded.[12] It also applied the 30% deficit reduction contribution rate to more plans and increased the lowest deficit reduction contribution rate from 13.75% to 18%. Thus, while one aim of the 1994 law was to encourage better funding of plans, it exempted some underfunded plans from deficit reduction contributions. The 1994 law was made effective for plan years beginning after December 31, 1994. The first year deficit reduction contribution is equal to $min\{0.30,[0.30 - 0.40*(\textit{funding status} - 0.60)]\}$ times the underfunding, so that the minimum deficit reduction contribution percentage is 18% for a funding status of 90%.[13,14]

Figures 2a and 2b show these requirements in graphical form. Figure 2a scales the required contributions by the percent of the underfunding that must be contributed, and Figure 2b shows values in dollar terms. These figures are drawn for a sample firm with mean characteristics. For a given plan's funding status, the firm must contribute the *greater* of the minimum funding requirement and deficit reduction contribution. The deficit reduction contribution as a percentage of the underfunding is given by the solid line for the post-1995 period and by the jagged line for 1987-1994. The minimum funding contribution is represented by the dashed line. The normal cost component of the minimum funding contribution is invariant to the degree of underfunding, which is why the minimum funding contribution as a percent of underfunding rises sharply as the funding status improves. The primary discontinuity is where the required contribution falls to zero at the point of full funding.[15]

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[12] For an 80-90% plan to be exempt, it must have been more than 90% funded for the two previous years.

[13] The permissible interest rates and actuarial assumptions for calculating the pension liability also changed over time. The original ERISA discount rate was based on the expected return on plan assets. The interest rates used to determine the funding status between 1987 and 1994 were 90%-110% of the four-year weighted average of thirty-year Treasury Bond rates. The 1994 law shrank the possible discount rate factor range to 90%-105%, and required all underfunded tables to apply the GAM 83 mortality table. The top was widened to 120% for 2002 and 2003.

[14] The 1987 and 1994 laws also affected the maximum amount that an employer may contribute. Under ERISA, the firm could contribute up to point where the plan was fully funded based on the ERISA liability. Since the ERISA discount rates were quite permissive, 1987 legislation put a cap on the funding limit to make it no more than 150% of the current liability. The 1994 law put a floor on the funding limit so that it would never be less than the threshold level for deficit reduction contributions. In 1997 Congress passed a gradual increase of this "ceiling factor" from 155% in 1999 to 170% in 2005. The EGTRRA passed in 2001 accelerated this increase; as of 2004 the "ceiling factor" will be phased out completely.

[15] For the firm with mean characteristics, the crossing of the two rules happens below the level of 90% funding. Depending on the relative size of the liabilities, the normal cost, and prior credits, the crossing may happen above 90%, in which case there will be yet another jump at 90% funding.

Using these rules for deficit reduction contributions and minimum funding requirements, I construct a measure of mandatory pension contributions, which I describe further in section 3. I use this simulated mandatory contributions variable as a factor that shifts the firm's financial resources in investment equations, and I argue that other sources of heterogeneity are absorbed by controls for the funding status itself.

There are to be sure other incentives for firms to shore up underfunded pension plans. Firms that are sufficiently overfunded are exempt from Pension Benefit Guaranty Corporation (PBGC) insurance premiums. As of 2003 these premiums were $19 per employee per year, plus $9 per $1,000 of shortfall. Furthermore, credit rating agencies may take unfunded pension liabilities into account, and unfunded liabilities may raise a company's cost of capital through that channel. It is possible that by contributing a dollar to the pension fund, a firm may reduce PBGC insurance premiums and its probability of a rating downgrade in such a way that the value of the firm is increased.

Nevertheless, in a world of perfect capital markets, the contributions a firm is *required* to make should have no effect on a firm's capital expenditure decision. If there are differential costs of internal and external finance, mandatory contributions are a drain on internal cash and would lower investment. The model in the next section illustrates this point.

2.2. A Two-Period Investment Model with a Shift to Internal Cash

The two-period models of Froot, Scharfstein and Stein (1993) and Kaplan and Zingales (1997), define the net present value of investment as

$$F(I) = \frac{f(I)}{1+r} - I \qquad f_1 > 0, f_{11} > 0 \tag{1}$$

where r equals the opportunity cost of internal funds. Investment may be financed out of internal funds *(w)* or external funds *(e)*:

$$I = w + e \tag{2}$$

and the firm must pay an external finance cost of

$$C = C(e, \theta) \qquad C_1 > 0, C_{11} > 0, C_2 > 0 \tag{3}$$

where C represents the costs of external finance. The source of the cost wedge between internal and external funds may be asymmetric information as in Myers and Majluf (1984) and Greenwald, Stiglitz, and Weiss (1984), or incentive and agency problems as in the models of Jensen and Meckling (1976), Grossman and Hart (1982), Stulz (1990) and Hart and Moore

(1995).[16] θ is a firm-specific type that signifies the extent of the informational or agency problems faced by the firm, such that C is increasing in θ.

I modify this framework to account for separate components of cash flow that are endogenous and exogenous to investment opportunities. For a firm with a defined benefit pension plan that is subject to periodic required contributions, internal financial resources *(w)* now comprise a non-pension component and a possible pension contribution. Assuming for tractability that pension liabilities are fixed and all shortfalls must be made up immediately, internal financial resources may be written as

$$\begin{aligned} &w = w_{NP} - PC \\ &PC = max(\overline{PL} - PA, 0) \end{aligned} \tag{4}$$

For the sake of exposition, suppose that a firm's investment opportunities and its current non-pension cash flow may be systematically related, but that pension contributions and its determinants are not correlated with investment opportunities. To formalize the correlation between investment opportunities and current cash flow in a general way, the production function has a parameter α that is an increasing function of non-pension cash flow. This would be the case if, for example, realized cash flows were an observable proxy for an underlying stochastic investment productivity parameter which was unknown at the time that the assets that generated the cash flow were originally put in place. Equation (1) becomes:

$$\begin{aligned} &F(I) = \frac{f(I,\alpha)}{1+r} - I \\ &\alpha = \alpha(w_{NP}), \alpha_1 > 0 \\ &f_1 > 0, f_2 > 0, f_{11} < 0 \end{aligned} \tag{5}$$

I allow as in Stulz (1990) and Stein (2001) that managers may obtain private benefits from output so that the managerial objective function is:

$$\begin{aligned} &\max_I \frac{(1+\gamma)f(I,\alpha)}{1+r} - I - C(e,\theta) \\ &s.t.\ \ I = w_{NP} - PC + e \end{aligned} \tag{6}$$

where $\gamma \geq 0$. This is an alternative way to represent agency costs. If internal cash is sufficiently large and $\gamma > 0$ there will be overinvestment relative to the first best. The program (6) generates the first-order condition for investment:

[16] The cost of external finance may also be related to the debt overhang problem of Myers (1977). Raising external finance with debt may decrease the willingness of investors to provide equity finance when creditors are first in line, if debt is underwater in some states. An alternative way to represent the debt overhang problem without explicitly introducing financing costs is to embed a pension funding decision in a three-period model of imperfect contracting such as Hart and Moore (1995). It can be shown that this yields similar predictions to the model considered in this section.

$$\lambda f_1(I^*,\alpha) - 1 = C_1(I^* - w_{NP} + PC, \theta) \tag{7}$$

where λ = (1+γ)/(1+r). Differentiation of this equation yields various comparative-static relationships.

a.) Differentiation of (7) with respect to non-pension cash flow (w_{NP}) yields:

$$\frac{dI^*}{dw_{NP}} = \frac{C_{11} + \lambda f_{12}\alpha_1}{C_{11} - \lambda f_{11}} \tag{8a}$$

Although the denominator is always positive, the numerator cannot be unambiguously signed. The derivative of α with respect to non-pension cash flow (α_1) is positive by assumption, but the derivative of the marginal product of investment with respect to α is unsigned. If f can be written as $f(I,\alpha) = g(\alpha)h(I)$ then given the restrictions on f in equation (5), f_{12} would be positive and any apparent positive response of investment to internal resources might completely reflect the correlation between cash flow and investment opportunities. If f cannot be written in this way, α might affect the shape of f in such a way that f_{12} is negative. Then dI^*/dw_{NP} would be *lower* than the firm's response to a cash shock with investment opportunities held constant. In either case, if investment opportunities depend on cash flow, the coefficient on cash flow in an investment regression is not a valid measure of the firm's response to a cash shock with investment opportunities held constant.

b.) Differentiation of (7) with respect to pension contributions (*PC*) yields:

$$\frac{dI^*}{dPC} = \frac{-C_{11}}{C_{11} - \lambda f_{11}} \tag{8b}$$

which is unambiguously negative. It is indeterminate whether $|dI^*/dw_{NP}|$ is greater than or less than $|dI^*/dPC|$. It is interesting to note that this sensitivity falls as λ gets larger, so that a higher agency parameter (γ) implies a lower sensitivity and a higher discount rate (r) causes a higher sensitivity, holding other factors constant.

An important question is whether the magnitude of the sensitivity (8b) is increasing in θ, the external finance cost parameter. Kaplan and Zingales (1997) derive a similar expression and point out that its derivative with respect to θ is not unambiguously signed. The derivative of (8b) with respect to θ is

$$\frac{d^2 I^*}{dPCd\theta} = \frac{-\lambda f_{11} C_{112}}{(C_{11} - \lambda f_{11})^2} \tag{9}$$

The sign of this expression is the same as the sign of C_{112}, which is indeed not unambiguously signed. An argument analogous to the signing of f_{12} in equation (8a) can be made here. If the cost function is separable in θ and e such that $C(e,\theta) = t(\theta)C(e)$, and if $t_1 > 0$, then $C_{112} = t'(\theta)C''(e) > 0$ and the sensitivity of investment to the exogenous cash component is increasing with the measure of constraint. If C cannot be written in this way then investment may not be increasing with the constraint parameter.

The main predictions of this model may be summarized as follows. If there are costs of external finance and underfunded pensions must be replenished, the pension funding status affects optimal investment if the firm's pension is underfunded, but not if it is overfunded. If cash flow is correlated with investment opportunities, then the simple regression relationship will not correctly estimate the response of the firm to an exogenous change in financial resources, and the direction of the error is not determined. If there is a negative component of cash flow that is not related to investment opportunities, then capital expenditures should fall as this component rises. Finally, the derivative of this sensitivity with respect to the external finance cost parameter is not unambiguously signed. If the effect of the cost parameter on the cost of external finance can be separated into a monotonically increasing function then the sensitivity to the exogenous component rises with proxies for the cost parameter.

In the results that follow, I find that the response to the cash drain from pension contributions is considerably *larger* than the coefficient on cash flow in investment regressions, suggesting that investment-cash flow sensitivities actually *underestimate* the response of investment to an shift in internal resources holding investment opportunities constant. I also find that this response to mandatory pension contributions rises with plausible proxies for the cost of external finance.

2.3 Central Empirical Specification Compared to Other Studies

A large investment literature (see for example Fazzari, Hubbard, and Petersen (1988), Kaplan and Zingales (1997), and Baker, Stein and Wurgler (2003)) scales variables by assets or capital and estimates linear equations of the form:

$$\frac{I_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 Q_{i.t-1} + \beta_2 \frac{CF_{i,t}}{A_{i,t-1}} + \varepsilon_{it} \tag{10}$$

where the dependent variable is the ratio of capital expenditures to assets. $Q_{i,t-1}$ is generally average Q as of the beginning of year t as represented by a market-to-book ratio of asset values. $CF_{i,t}$ is a measure of cash flow. A linear relationship between investment and *marginal Q* is generally derived using a model of investment in which firms pay adjustment costs $\Psi(I,K)$ with the property that Ψ_I is linear in I/K; alternatively, adjustment costs may be expressed as an installation function $\psi(I,K)$ which is linear homogeneous in I and K (see Hayashi (1982)). This condition and the linear homogeneity of the production function itself are together necessary and sufficient conditions for marginal Q to equal the ratio of the market value of existing capital to its replacement cost (see Hayashi (1982) and Erickson and Whited (2000)).

Fazzari, Hubbard, and Petersen (1988) motivate the addition of cash flow to this specification by reducing the value of the firm by an information premium per dollar of new equity issued. However, a series of studies raise objections to interpreting differential investment-cash flow sensitivities (estimates of β_2) as indicative of differential financing constraints. One group of issues relates to potential measurement error in Q. This problem was first conveyed by Poterba (1988), who argues that if inferences drawn from differential investment-cash flow sensitivities across groups of firms may simply reflect differential measurement error in Q across these groups. Erickson and Whited (2000) discuss other potential sources of measurement error in Q, including the potential divergence of average Q from the commonly measured Tobin's Q. A second category of doubts about investment-cash flow sensitivities begins with Kaplan and Zingales (1997), who show empirically that firms who appear to be least constrained in fact have higher investment-cash flow sensitivities. Alti (2003) demonstrates with simulated data that under certain conditions there can be correlations between cash-flow and Q in specifications such as (11) even without financing constraints. In particular, this happens when average Q is an inadequate proxy for investment opportunities. Moyen (2004) uses simulated data to demonstrate that constrained firms may have lower cash flow sensitivities than unconstrained firms, even though low-dividend firms may have higher cash flow sensitivity than high dividend firms.

My approach moves away from investment-cash flow sensitivities by examining the response of investment to shifts in internal cash that are not related to the firm's operating income. This is most related to Blanchard, Lopes-de-Silanes and Shleifer (1994) and Lamont (1997), who isolate such shifts in very small, specialized samples.[17,18] I separate cash flow into

[17] There are also studies that examine the sensitivity of investment to cash flows arising from voluntary activities. For example, Titman and Hovakimian (2003) examine the sensitivity of investment to funds from voluntary asset sales. The fact that these sales are voluntary complicates the interpretation of changes in investment with which they are correlated.

non-pension cash flow and *mandatory pension contributions*. I argue that the latter is exogenous to a firm's investment opportunities and its overall operating environment when controlling for non-pension cash flow, Tobin's Q, and the funding status itself. My primary specification is:

$$\frac{I_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 Q_{i.t-1} + \beta_2 \frac{NonPensionCashFlow_{i,t}}{A_{i,t-1}} + \beta_3 \frac{Z_{i,t}}{A_{i,t-1}} + X'\Gamma + \varepsilon_{it} \tag{11}$$

where $Z_{i,t}$ is a pension-related factor, such as mandatory contributions or the funding status itself, that shifts internal cash resources. X is an additional vector of controls, including the funding status itself when $Z_{i,t}$ is mandatory contributions. This specification includes year and firm fixed effects.[19]

Theory does not dictate that pension plan variables be exogenous to investment opportunities. However, by setting Z_{it} to be required contributions and including linear and nonlinear functions of the funding status in X_{it}, I exploit the fact that mandatory contributions are a kinked and discontinuous function of the funding status. Other than a direct response of investment to internal resources, there is no reason that investment should exhibit a response to mandatory contributions when the funding status is controlled for. In the labor economics literature, this is known as a regression discontinuity (RD) identification method (see Angrist and Lavy (1999), and Angrist and Krueger (1999)). In addition, the approach represented by equation (12) has the advantage that non-pension cash flow does not need to be exogenous to investment opportunities for the model to be correctly specified. Non-pension cash flow in this context may in fact be viewed as partially capturing investment opportunities. The key requirement is that the variable $Z_{i,t}$ that shifts internal financial resources be exogenous in the presence of the other controls. This variable can then also be used in two-stage regressions as an instrument for an endogenous component of cash flow, such as non-pension cash flow or total (mandatory plus voluntary) contributions.

3. Data Description and Construction of Variables

The primary data used in this analysis is an unbalanced panel of Compustat firms reporting defined benefit pension assets that also made an IRS 5500 filing between 1990 and

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[18] Another notable study is Almeida, Campello, and Weisbach (2004) argue that the cash flow sensitivity of cash itself is a better measure of financing constraints than the cash flow sensitivity of investment, as liquidity management is only value-enhancing for constrained firms.

[19] One way this could be motivated structurally would be to replace the usual adjustment cost function $\Psi(I,K)$ in the standard intertemporal investment model with a generalized cost function that includes both external financing costs and the usual adjustment costs: $\Omega(I,K,f(K), v) = \Psi(I,K) + C(I, f(K), v)$. External finance is determined by investment, contemporaneous cash flow, and an exogenous (e.g. pension related) cash shock v. If the assumption that Ψ_I is linear in I/K is maintained, and C_I is also linear in I/K, $f(K)/K$, and v/K, then equation (12) emerges from the usual first order conditions. A simple and plausible functional form that has this property is $C(I,f(K),v)=(I - f(K) + v)^2/K$.

1998.[20] The IRS 5500 filings contain data on ABO funding status and normal cost at the plan level which are necessary to calculate required contributions.[21] The size of the sample is 8,030 firm-year observations on 1,522 firms. Appendix Table 1 illustrates the construction of the sample from Compustat. A number of firms in the Compustat sample of firms with pension assets were not able to be matched to the IRS filings because their plans were not large enough to trigger an IRS 5500 filing on the main form.[22] Many firms that do have filings in the IRS 5500 data set are not used because they are not publicly traded. Plan-level data on firms with multiple plans with the same fiscal year-end dates were aggregated to the firm level, with separate statistics maintained for overfunded and underfunded plans. Some firm-years were discarded because the firm had several plans whose fiscal years ended in different months. The final sample consists of approximately half of Compustat firms with defined benefit pension assets.

Summary statistics for the sample are presented in Table 1. Unconditional means, medians, standard deviations, and nonzero observation counts are presented in the left panel. Values at the 10th, 25th, 50th, 75th, and 90th percentiles of the distribution conditional on the variable being nonzero are presented in the right panel. All variables are winsorized at the 1st and 99th percentiles in order to protect the results from the effects of extreme outliers. Variables subscripted with *-1* may be thought of as the value as of the beginning of year. Unless otherwise indicated, all variables are scaled by beginning of year balance sheet assets, A_{-1} (data6). Capital expenditures (data128) have a mean value of 6.9% of beginning-of-year assets and a median of 5.8% of beginning-of-year assets. There are several groups of variables whose construction requires further explanation.

Tobin's Q is constructed as the market-to-book ratio of firm assets.[23] The numerator equals the market value of equity plus book assets minus the sum of the book value of common equity and deferred taxes. The denominator is assets at book value. The mean *Q* for the sample

[20] 1990 is the first year for which the OBRA 1987 funding status is provided on the form, and 1998 is the final year for which the research dataset is available.

[21] Compustat pension data have a number of drawbacks. The data arrive aggregated to the firm level, so that they do not capture intra-firm variation in the funding status of plans. Pension liabilities are calculated using the projected benefit obligation (PBO) method, in which prospective salary increases are taken into account. Also, domestic and international pension assets are aggregated into one pension asset variable and one pension liability variable. Mandatory contributions are determined on a plan-by-plan basis for domestic pension plans only.

[22] Sponsors of plans with fewer than 100 participants during this period filed the Form 5500-C, the Form 5500-R, or the Form 5500-C/R.

[23] To be exactly Tobin's *Q*, the book value of assets should be adjusted to more accurately reflect replacement costs. Perfect and Wiles (1994) suggest that this adjustment is not critical.

is 1.48, and the median is 1.26.[24] This compares to a mean Q of 1.84 and a median Q of 1.20 for the entire Compustat universe, reflecting the fact that the DB pension companies have a lower tendency to be growth companies than average firm in the universe as a whole.

Cash flow variables: Previous studies of investment such as Kaplan and Zingales (1997) and Baker, Stein and Wurgler (2003) have defined cash flow as net income plus depreciation and amortization (data18 + data14). The rationale behind adding depreciation and amortization back to the bottom line is that these are non-cash charges. Another non-cash charge that should be added back to net income in deriving cash flow is the pension expense that is generally subtracted on the income statement. This pension expense is only loosely related to the true cash demands of the pension plan, which are the actual contributions the firm must make to the plan. The income statement's pension expense is determined largely by the amount of additional liabilities that the firm accrues during the year (the service cost), as well as the effect of the liabilities drawing one year closer (the interest cost) and the expected rate of return on plan assets.[25] Actual contributions are not represented on the income statement but are found at the plan-level in the IRS 5500s. I therefore define two cash flow variables:

$$CashFlow = \underset{data18}{NetIncome} + \underset{data14}{DA} + \underset{data43}{PensionExpense} - \underset{IRS5500s}{PensionContributions}$$

$$NonPensionCashFlow = \underset{data18}{NetIncome} + \underset{data14}{DA} + \underset{data43}{PensionExpense}$$

Cash flow and non-pension cash flow are 9.6% and 9.9% of book assets respectively at the median. Pension contributions represent 0.3% of assets at the conditional median and 1.3% of assets at the conditional 90th percentile. For the Compustat universe as a whole during the 1990-1998 period, non-pension cash flow over assets is 6.4% at the median, reflecting a larger return on assets of the companies in the sample compared to the universe as a whole.

Pension Funding Status and Mandatory Contributions: Firms may have several pension plans. The overfunding in overfunded plans may not be applied against the underfunding in underfunded plans. For each observation, separate variables are created for overfunded and underfunded plans, as overfunding and underfunding have different predicted effects on investment. $Underfunding_{i,t}$ is defined as the sum of the shortfall in underfunded pension plans, and $Overfunding_{i,t}$ as the sum of the surplus in overfunded plans. Using k to represent the plan number for a given firm-year, the funding variables for firm i at time t may be written:

[24] Fazzari, Hubbard, and Petersen have median Q values of 1.6, 1.4, and 1.0 in their three samples (from lowest to highest dividend yield).

[25] Firms with pension plans subtract an expected rate of return on pension assets from their pension costs, even if this is very far away from the actual return on plan assets. See Bergstresser, Desai and Rauh (2003).

$$Underfunding_{i,t} = \sum_k Underfunding_{i,t,k} = \sum_k \max\left[PL_{i,t,k} - PA_{i,t,k}, 0\right]$$
$$Overfunding_{i,t} = \sum_k Overfunding_{i,t,k} = \sum_k \max\left[PA_{i,t,k} - PL_{i,t,k}, 0\right] \quad (12)$$

For the period 1990-1994, $PL_{i,t,k}$ is the current liability reported on the IRS 5500 using 1987 discount rate and mortality rules. For the period 1995-1998 it is the current liability using the 1994 discount rate and mortality rules. The variables of interest are the funding variables as of the beginning of the year scaled by the firm's balance sheet (non-pension) assets. Firms with underfunded plans have underfunds ranging from 0.1% of assets at the conditional 25th percentile to 3.2% of assets at the conditional 90th percentile.

Total annual contributions may contain both required and discretionary components. *Mandatory pension contributions* are a constructed estimate of the firm's required contributions, with formulas based on the laws described in section 2.1 and the actuarial treatment of Winklevoss (1993).[26] Mandatory contributions are zero for firms with no underfunded pension plans. For firms with underfunded plans the laws explained in section 2.1 and represented pictorially in Figures 2a and 2b stipulate that they are the maximum of two components: the deficit reduction contribution (DRC) and the minimum funding contribution (MFC).[27]

As described in section 2.1, the DRC rule was changed by the Retirement Protection Act of 1994. For this reason, there are different formulas for 1990-1994 and 1995-1998. For plan k of firm i at time t, the DRC is given by:

1990-1994 $\quad DRC_{i,t,k} = [0.30 - 0.25 * (FS_{i,t,k}^{(87)} - 0.35)] * Underfunding_{i,t,k}$ if $FS_{i,t,k}^{(87)} < 1$ (13a)

$\quad DRC_{i,t,k} = 0$ if $FS_{i,t,k}^{(87)} \geq 1$

1995-1998 $\quad DRC_{i,t,k} = [0.30 - 0.40 * (FS_{i,t,k}^{(94)} - 0.60)] * Underfunding_{i,t,k}$ if $FS_{i,t,k}^{(94)} < 0.9$ (13b)

$\quad DRC_{i,t,k} = 0$ if $FS_{i,t,k}^{(94)} \geq 0.9$

where $Underfunding_{i,t,k}$ is given by equation (13), $FS_{i,t,k}^{(87)} = \frac{PA_{i,t,k}}{PL_{i,t,k}^{(87)}} - 1$, and $FS_{i,t,k}^{(94)} = \frac{PA_{i,t,k}}{PL_{i,t,k}^{(94)}} - 1$.

I follow Zion and Carcache (2002) in approximating the MFC as the sum of the normal cost and 10% of the underfunding from the first year. However, I also build in two refinements based on the treatments in Munnell and Soto (2003), Winkelvoss (1993), and Langbein and Wolk

[26] See Winkelvoss (1992), p. 140.

[27] An underfunding in a given year may trigger required contributions in future years if the firm does not return the plan to fully funded status. This is because the laws require amortized payments. However, firms whose plans do return to health will often not have to contribute previously amortized amounts. I define DRC and MFC as the deficit reduction contributions and minimum funding contributions due in the first year alone.

(2000). First, the MFC uses a different liability measure for calculating the funding status, the rules for which are provided by ERISA.[28] Second, the MFC may be offset with credits built up from prior years. The MFC for plan *k* of firm *i* at time *t* is therefore:

$$MFC_{i,t,k} = \max\left(NormalCost_{i,t,k} + 0.10 * Underfunding_{i,t,k}^{ERISA} - PriorCredits, 0\right) \quad \text{if } Underfunding_{i,t,k} > 0 \tag{14a}$$

$$MFC_{i,t,k} = 0 \quad \text{if } Underfunding_{i,t,k} = 0\,. \tag{14b}$$

Initially there were 24,879 plan-year observations on the 12,834 firm-year observations that were matched to Compustat (see Appendix Table 1). Of these 24,879 plans, 7,424 were underfunded. Of the 7,424 underfunded plans, 1,940 had *DRC* > *MFC* and 5,484 had *DRC* < *MFC*. The initial estimate of mandatory pension contribution for firm *i* at time *t* is:

$$\begin{aligned} MandatoryContribution_{i,t,k} &= \max(DRC_{i,t,k}, MFC_{i,t,k}) \\ MandatoryContribution_{i,t} &= \sum_k MandatoryContribution_{i,t,k} \end{aligned} \tag{15}$$

Figure 3 shows a univariate kernel density estimation of the difference between actual and required contributions.[29] The solid line represents the density of all observations, including those with zero actual contributions. The dashed line represents the density excluding observations with zero actual contributions. Actual contributions are clearly bunched around the point of estimated required contributions, suggesting that the contribution requirement is an important determinant of total contributions. Area under the curves to the right of zero represents voluntary contributions. The small area under the curves to the left of zero represents error in the mandatory contributions calculation, as a contribution level cannot be required if a firm manages to contribute less than that amount. This error could arise from a number of sources, including misreporting, running up against full funding limits, other prior amortization credits, or firms who are in bankruptcy and whose plans enter PBGC receivership. In these error cases the estimate of mandatory contributions is replaced with what a firm actually contributed.[30]

Of the 8,030 observations, 2,380 have nonzero mandatory contributions. The years with the fewest percentage of firms in the sample with positive mandatory contributions are 1990

[28] The discount rate for the ERISA liability is set by the plan's actuary. Munnell and Soto (2003) detail that the average discount rate used by final average pay pension plans increased from 5 percent in 1976 to 8 percent in 1986, but has not changed since then. The effect that changes in this rate may have on the ERISA liability are amortized over long periods of time.

[29] An Epanechnikov kernel is used and the bandwidth is given by the optimality formula of Silverman (1986), $h = min\left(\sigma_x, \frac{p75(x) - p25(x)}{1.349}\right) * 0.9n^{-1/5}$.

[30] This operation affects approximately 8% of observations, mostly by less than 0.1% of book assets. The results are not sensitive to the treatment of these cases, including dropping them entirely.

(27.6%) and 1998 (29.5%), and the year with the most was 1995 (52.0%). The means and distributions of estimated mandatory contributions as a share of book assets and of capital expenditures are depicted in Figure 4. In 1995, approximately 10% of firms in the sample had mandatory contributions that were more than 20% of the previous year's capital expenditures, 5% had mandatory contributions that were more than 1% of the firm's book assets, and 55% had at least one underfunded pension plan. At the 1995 mean, mandatory contributions were about 9% of capital expenditures, compared to an average of 4-5% for the rest of the sample years.

In addition to the 1990-1998 sample, estimates of mandatory contributions for 1999-2003 are calculated for Figure 4. For these years Compustat data must be used to approximate the IRS 5500 variables that are not available.[31] The simulated mandatory contributions for the period 1999-2003 reveal that the estimated required contributions in the year 2002 were nearly of the same magnitude as those from 1995, whereas the location of the estimated distribution for 2003 is considerably higher than all previous years. Almost 25% of firms in the sample are expected to have to make contributions in 2003 that are at least 20% of 2002 capital expenditures.

4. Results

This section proceeds as follows. In section 4.1, I show that the nonparametric relationship between pension funding and investment suggests an important role for internal financial resources in determining the level of corporate investment. In section 4.2, I consider the effects of mandatory contributions and funding status on capital expenditures by estimating linear parametric specifications of the form of equation (11). I consider alternative specifications as robustness checks, including industry-by-year controls, random effects, and first differences. I also examine the effects of pension contributions on alternative outcome variables, such as R&D, acquisitions, dividends, stock repurchases, and financing variables. In section 4.3, I consider the suitability of using pension-related variables as instruments in two-stage regressions of capital expenditures on cash flow, and I present the results of two-stage estimation. In section 4.4, I divide the sample by observable proxies for the cost of external finance, and I examine the results of the main specification in the these divided samples.

4.1 Nonparametric Evidence

Before estimating the parameters of the linear specifications developed in section 2, it is useful to examine the nonparametric relationship between pension funding and capital expenditures. A kernel regression allows such a relationship to be plotted between two variables

[31] See data appendix for details. So as not to make the results dependent on these approximation steps, the empirical exercises in this paper are carried out only on the 1990-1998 sample. The qualitative results are very similar on the longer, approximated sample, however.

without the imposition of a functional form.[32] Figure 5a shows nonparametric relationships between the funding status and capital expenditures (left scale) and between the funding status and contributions (right scale). Capital expenditures increase with the funding status but only up to the point of full funding, which is where mandatory contributions cease. This is precisely the relationship predicted if investment is sensitive to internal financial resources. Contributions, which here consist of both mandatory and voluntary contributions, decline as the funding status improves. The very low level of average investment for the most poorly funded firms cannot be completely explained by contemporaneous contribution requirements. However, the flatness of the relationship in the overfunded region and the apparent kink at the level of full funding clearly support the hypothesized dependence of investment on internal cash.

Figure 5b depicts nonparametric relationships between required contributions and capital expenditures (left scale) and between the required contributions and total contributions (right scale). The average capital expenditure value at zero mandatory contributions is just over 6.5% of assets, and total pension contributions are under 0.5% of assets. As mandatory contributions rise, total pension contributions appear to rise essentially one-for-one, and investment appears to fall at approximately the same slope. When mandatory contributions are equal to 1.5% of assets, investment is around 5.0%. This picture would be consistent of an almost complete offset of required contributions with cuts in capital expenditures.[33]

4.2 Pension Contributions, Funding Status, and Investment

Table 2 shows the estimation of panel regressions of capital expenditures on pension and non-pension cash flows. Specification (1a) is the standard specification from the literature and equation (10):

$$\frac{I_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 Q_{i.t-1} + \beta_2 \frac{CashFlow_{i,t}}{A_{i,t-1}} + \varepsilon_{it}$$

with cash flow defined as described in section 3. This is presented as a baseline and for comparison with other studies. The coefficient on cash flow (β_2) has a point estimate of 0.111

[32] In particular, it estimates functions of the form

$$\hat{f}(x) = [n^{-1}\sum_{i=1}^{n} K(X - X_i)Y_i] / [n^{-1}\sum_{i=1}^{n} K(X - X_i)]$$

where K is a kernel function. See Härdle (1990).

[33] For Figure 5a, the estimation is more precise towards the center of the graph and less precise towards the edges, as there are fewer observations with extreme funding statuses. For Figure 5b, it is most precise at the left side of the graph, and less precise at very high levels of required contributions.

and the coefficient on Q (β_1) has a point estimate of 0.019, which are broadly consistent with estimates found in other studies.[34]

The basic specification for the rest of Table 2 is equation (11):

$$\frac{I_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 Q_{i.t-1} + \beta_2 \frac{NonPensionCashFlow_{i,t}}{A_{i,t-1}} + \beta_3 \frac{Z_{i,t}}{A_{i,t-1}} + X'\Gamma + \varepsilon_{it}$$

where $Z_{i,t}$ is a pension-related factor that shifts cash flow, such as mandatory contributions. X is an additional vector of controls including funding status in some specifications. In specification (1b), Z is total pension contributions and there are no additional controls. In specification (1c), Z is mandatory contributions and there are again no additional controls. Total contributions have a positive coefficient that is statistically insignificant, whereas when mandatory contributions alone are considered, an effect of –0.830 with a heteroskedasticity-robust standard error of 0.289 is measured. This effect would imply that a $1 mandatory contribution would reduce capital expenditures by $0.83.

The middle panel of Table 2 adds the funding status variables to the specifications estimated in the left panel. In column (2a), there are no contribution variables.[35] The point estimate for $1 of underfunding is an effect of –$0.164 on capital expenditures, and the extent of overfunding does not affect investment. These coefficients are suggestive of an effect of the cash drain from required contributions on capital investment, but a more robust way of estimating the this effect is to examine the relationship between contributions and capital expenditures while controlling for the funding status variables themselves. In columns (2b) and (2c), Z is total pension contributions and mandatory pension contributions respectively, and the funding status variables are used as controls that belong to the matrix X. Controlling for the funding status in this way, mandatory contributions have an estimated effect of –0.607 on investment. This is an important specification, as it argues against the claim that heterogeneity in funding status is the main driver of the main mandatory contribution result from column (1c).[36]

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[34] The Q coefficient estimate is in the middle of the range of 0.012-0.033 found by Baker, Stein and Wurgler (2003), while the cash flow coefficient of 0.111 is at the low end of the Baker-Stein-Wurgler range of 0.110-0.145. Fazzari, Hubbard and Petersen (1988) found a cash flow coefficient of 0.461 and Q coefficient of 0.0008 for a 1970-1984 panel of low-dividend paying firms, using a somewhat different definition of Q. Kaplan and Zingales (1997) found a cash flow coefficient of 0.395 and a Q coefficient of 0.039 for the FHP panel.

[35] Specification (2a) may be thought of in terms of equation (12). Z may be considered the extent of underfunding itself, which determines the amount that the firm must contribute to its pension plans. The extent of overfunding is part of the control vector X.

[36] This includes the concern that there is correlation between the funding status and investment opportunities. It also takes care of other stories, such as correlations among managerial styles, pension fund investment, and cash flow sensitivity.

Specifications (3a)-(3c) of Table 2 add additional controls to the specifications (2a)-(2c), consisting of terms for the squares and cubes of the funding status variables (not shown). By controlling for smooth, nonlinear functions of the funding status variables, potential heterogeneity of investment patterns with respect to the funding status is modeled in an even more general way than the simple inclusion of linear funding status terms. Specification (3c) shows that even in the presence of these controls, required contributions have an effect of –0.597 on capital investment.

These estimates have acute implications for capital investment in the current pension funding crisis. The mean company in the sample has estimated required contributions of 23% of capital expenditures in 2003. The most conservative estimate (–0.597) predicts that investment will be lower for these firms by approximately 13.7% compared to what it would have been in the absence of these contributions. Given recent statements made by CEOs in the financial press, this estimate seems quite plausible.[37]

There are at least two caveats to this result, however. The first is that the standard errors are large enough such that the most definitive inference that can be drawn is that the response is statistically larger than zero. Second the methods presented in this section do not address the important general equilibrium question of what happens to the lost investment. The forgone investment may disappear forever, or it may be shifted to future time periods at the same firm. Alternatively, firms without underfunded pension plans may take up the projects that constrained and underfunded pension firms leave on the table, so that the contribution requirement essentially shifts investment from firms that sponsor DB pension plans to firms that sponsor DC pension plans. Section 5 considers these possibilities.

Table 3 makes modifications to the central specification that relates required contributions to capital expenditures with linear controls for the funding status variables.[38] The first regression contains both firm fixed effects and industry-by-year fixed effects, in contrast to the baseline of firm and year fixed effects only. The industry effects follow the 48-industry delineation of Fama and French (1997). The second and third columns estimate the specification

[37] Prominent examples include the motivating quote by the Caterpillar officer at the beginning of this paper, and recent comments by J.T. Battenberg III, CEO of Delphi Automotive, in the October 6, 2003 issue of *Newsweek* magazine: "To fill that hole [a $4.1 billion shortfall in Delphi's pension fund], Battenberg is shoveling some $600 million a year—about half of Delphi's available cash—into the fund. 'It's a huge millstone,' he grumbles. 'We are delaying our expansion plans because our board suddenly has half the amount of cash you would normally have.... A lot of economists wonder why corporate America is so cautious,' says Battenberg. 'We're cautious because of the uncertainties surrounding this pension obligation.'"

[38] The baseline specification for Table 3 is therefore column (2c) in Table 2.

by random effects (RE) and first differences (FD) respectively.[39] Random effects is consistent and efficient if the individual-specific effects are uncorrelated with the observation-specific error term. A simple Hausman test narrowly rejects the use of random effects in this context. The FE estimator is more efficient than the FD estimator when the error terms within firms over time are not serially correlated. The FD estimator is more efficient when the error terms follow a random walk (see Wooldridge (2001)), although the loss of 15-20% of the unbalanced panel through the differencing process also would tend to make the estimates less accurate. Hausman tests on the vector of all coefficients and their standard errors would reject that these vectors have the same probability limit, which poses a number of interesting questions for future research on linear investment models.[40] However, the coefficients on mandatory contributions in these three alternative models are not statistically distinguishable from one another or from the main results in Table 2.

The right panel of Table 3 estimates the central specification with alternative funding status controls. The level of mandatory contributions is determined by both the dollar amount of the underfunding and by the percent underfunding relative to liabilities. In the models in Table 2, the funding status controls are functions of the dollar amount of the underfunding. In the right panel of Table 3, I test the sensitivity of the results to controlling for the percent underfunding and overfunding. The first column of this panel controls for the percent funding status for underfunded and overfunded plans. The percent funding status is defined as assets in the plan over liabilities in the plan. The second column adds to this a control for the size of plan assets relative to book assets, as this is not captured by the percent funding status. The third column controls for both the level and the percent funding status with squares and cubes of all four funding status variables. The effect of mandatory contributions on investment persists even in this very strict specification, though some precision is lost.

Capital expenditures are only one of the many uses of funds that firms could reduce in response to the cash drain from pensions. In Table 4, I examine the effects of mandatory contributions on other uses of funds: research and development, acquisitions, dividends, stock repurchases, and financing variables. The financing variables considered are changes in book

[39] An alternative model not presented here would be to estimate pooled regressions using OLS with adjusted standard errors, or to estimate OLS year-by-year and average the coefficients by year as in a Fama-MacBeth (1973) procedure. These methods yield coefficients on mandatory contributions that range from –0.45 to –0.78, despite not controlling for unobserved firm-specific effects.

[40] The difference between the fixed effects (FE) and first difference (FD) models may be driven by the sample reduction when the data is first differenced. If not, the difference would call into question the strict exogeneity assumption on Q and cash flow in the literature that estimates linear investment equations. These assumptions need to be investigated in the larger Compustat universe.

equity, changes in retained earnings, changes in outstanding debt, and changes in trade credit.[41] The equations in Table 4 are all of the baseline form

$$\frac{Y_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 Q_{i.t-1} + \beta_2 \frac{NonPensionCashFlow_{i,t}}{A_{i,t-1}} + \beta_3 \frac{Z_{i,t}}{A_{i,t-1}} + X'\Gamma + \varepsilon_{it} \tag{16}$$

In the top panel, Z is mandatory contributions and X consists of the funding status variables. In Panel 2, Z is the extent of underfunding and X is the extent of overfunding. In the top panel, only capital expenditures show a statistically significant decline in response to required contributions. In the bottom panel, only capital expenditures and repurchases fall significantly with the extent of underfunding. While it cannot be definitively concluded from these results that no other cash uses are affected, the table does suggest that capital expenditures are the most important use of funds that is crowded out by required contributions.

4.3 Contribution Behavior and Two-Stage Estimation of Investment Equations

A variant of the main regressions of capital expenditure on funding status involves a two-stage instrumental variables (IV) estimation procedure. Capital expenditures are regressed on the control variables and the predicted level of contributions:

$$\begin{aligned} \frac{CAPX_{i,t}}{A_{i,t-1}} &= \alpha_{2t} + \beta_{21} Q_{i,t-1} + \beta_{22} \frac{NonPensionCF_{i,t}}{A_{i,t-1}} + \beta_{23} \frac{Contribs_{i,t}}{A_{i,t-1}} + X'\Gamma_2 + \varepsilon_{i,t} \\ \frac{Contribs_{i,t}}{A_{i,t-1}} &= \alpha_{1t} + \beta_{11} Q_{i,t-1} + \beta_{12} \frac{NonPensionCF_{i,t}}{A_{i,t-1}} + \beta_{13} \frac{Z_{i,t}}{A_{i,t-1}} + X'\Gamma_1 + \upsilon_{i,t} \end{aligned} \tag{17a}$$

or the predicted level of cash flow:

$$\begin{aligned} \frac{CAPX_{i,t}}{A_{i,t-1}} &= \alpha_{2t} + \beta_{21} Q_{i,t-1} + \beta_{22} \frac{CashFlow_{i,t}}{A_{i,t-1}} + X'\Gamma_2 + \varepsilon_{i,t} \\ \frac{CashFlow_{i,t}}{A_{i,t-1}} &= \alpha_{1t} + \beta_{11} Q_{i,t-1} + \beta_{12} \frac{Z_{i,t}}{A_{i,t-1}} + X'\Gamma_1 + \upsilon_{i,t} \end{aligned} \tag{17b}$$

The first-stage equation involves a variable $Z_{i,t}$ that is excluded from the capital expenditure equation. The assumption behind this specification is that the instrument $Z_{i,t}$ affects capital expenditures only though its effect on the first-stage dependent variable, when controls X are present.

Although this identifying assumption is not testable, it is useful before conducting this estimation to investigate the determinants of contributions within firms over time. If it appears that mandatory contributions are systematically high when investment opportunities are weak

[41] Book equity includes deferred taxes, i.e. (data60 + data74). Retained earnings are from company financial statements (data36). Outstanding debt is total assets at book value minus book equity. Trade credit is accounts payable (data70) minus accounts receivable (data2).

then mandatory contributions may not be a valid instrument. To study this further I estimate equations of the form:

$$\frac{Contributions_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_{11} Q_{i,t-1} + \beta_{12} \frac{NonPensionCashFlow_{i,t}}{A_{i.t-1}} + X'\Gamma + \upsilon_{i,t} \qquad (18)$$

Table 5 shows the results of estimating equation (18) in the 1990-1998 sample. The left panel considers mandatory contributions. The theoretical determinants of mandatory contributions have been established in the previous sections: they depend on the funding status. With no controls other than firm and year fixed effects, column (1a) shows no relationship between current mandatory contributions and operating environment variables such as Q and non-pension cash flow. Column (1b) illustrates that there is some serial correlation in mandatory contributions, with lagged mandatory contributions having a statistically significant coefficient of 0.223 on mandatory contributions in the next period. To the extent that firms smooth investment over time in anticipation of future cash restrictions, this correlation should work against finding significant effects of required contributions on investment. Column (1c) shows that controlling for the funding status, mandatory contributions are effectively uncorrelated with Tobin's Q and with non-pension cash flow. Each dollar of underfunding appears to generate $0.147 in mandatory contributions, and overfunding has no effect, as expected. Column (1d) estimates the same specification as (1c) but uses Tobit estimation instead of fixed effects. Tobit is a pooled specification, so the results are not directly comparable to the panel specifications. Here, there is a statistically significant and negative relationship between Tobin's Q and mandatory contributions, though the magnitude of this correlation is very small. Given two otherwise identical observations, it would require a one point difference in Tobin's Q holding cash flow constant (through an exogenous doubling of the stock price for example), for mandatory contributions to be lower by only 0.02% of assets, and this effect does not appear at all in the within-firm regressions. Column (1d) therefore highlights the importance of using fixed-effects in the main two-stage specifications.

The right panel of Table 5 presents similar estimation on voluntary contributions. There are several reasons that firms might make voluntary contributions. Managers might believe that investing additional cash in the pension fund is a positive net present value investment on behalf of the shareholders, despite the fact that the shareholders may not easily be able to get the cash out of the fund. The investment might well be profitable if the firm is responding to other incentives to fund the pension (e.g. exemption from PBGC insurance premiums). The investment might also be value enhancing if firms are aware of the wedge between internal and external finance. If they are forward-looking about potential cash shortfalls (as in Gross (1995)), they

might make contributions to avoid external finance problems in the future. Managers may also make decisions on the margin between paying the cash out to shareholders and depositing it into the pension fund, and there may be agency or asymmetric information reasons they prefer to keep the cash in the firm. Voluntary contributions as presented in the right panel of Table 5 appear to have either zero or a very small negative relationship with Tobin's Q. They are higher when non-pension cash flow is higher, but only by a maximum of $0.014 per dollar of non-pension cash. They are higher the more underfunded assets the plan has, and lower the more overfunded plan assets the firm has, though the latter effect is smaller. There is also some serial correlation in voluntary contributions, and a positive relationship with lagged mandatory contributions.

With these results in mind I estimate two-stage fixed-effects regressions of capital expenditure on cash flows, using mandatory contributions or funding status variables as instruments. Table 6 presents six two-stage regressions, all using capital expenditures as the second-stage dependent variable. The first four columns are analogous to equation (17a), in which mandatory contributions or funding status variables are used as instruments for total contributions. The second two columns are analogous to equation (17b) in which mandatory contributions or funding status variables are used as instruments for total firm cash flow.

The six equations give largely the same picture as one another, and as the one-stage estimation. In column (1a), instrumented contributions have an estimated effect of –0.852 on investment, significant at the 1% level. There is an approximately one-for-one relationship between mandatory contributions and total contributions, suggesting that mandatory contributions neither crowd out nor encourage voluntary contributions. In column (1b), funding status variables are included as controls and the effect of instrumented contributions is still –0.782. Each dollar of required contributions increases total contributions by $0.777, so that required contributions do appear to crowd out some voluntary contributions. Column (1c) dispenses with the mandatory pension contribution construction and use only the pension funding variables as instruments. Column (1d) uses the extent of underfunding as the instrument (Z) and includes overfunding as a control (X) in both equations. The identifying assumption for this latter specification is that the extent of underfunding affects investment only though its effect on pension contributions when the overfunding variable is present as a control.[42] In columns (1c) and (1d), the point estimate of the magnitude of the effect on total investment of a dollar of contributions is even larger than in (1a) and (1b).

[42] A regression of non-pension cash flow on Q and the funding status reveals that the extent of underfunding does not appear systematically related to non-pension cash flow (and hence to investment opportunities), though the extent of overfunding may be. This result speaks in favor of an approach that uses underfunding as an instrument and overfunding as a control.

Specifications (2a)-(2b) estimate equation (17b) using mandatory contributions and the extent of underfunding respectively as instruments for total cash flow. The appeal of this approach is that the coefficient on cash flow can be interpreted as a true investment-cash flow sensitivity holding investment opportunities constant. The drawback is that the standard errors are larger than in the other specifications, due perhaps to the weakness of the instrument in the context of the total variation in cash flow. Mandatory contributions explain less than 1% of the total variation in cash flow, so the R-squared of 0.11 in the first stage is almost completely due to the positive relationship between Q and cash flow. In these specifications, a $1 decrease in a company's total cash flow is estimated to reduce investment by $0.60-$0.70.

4.4 Division of Sample by Observable Measures of Financing Constraints

Previous studies have debated the merits of various observable characteristics as indicators of financing constraints. In Table 7 I divide the sample on some of these characteristics and estimate the baseline one-stage specification

$$\frac{I_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 Q_{i.t-1} + \beta_2 \frac{NonPensionCashFlow_{i,t}}{A_{i,t-1}} + \beta_3 \frac{MandatoryContributions_{i,t}}{A_{i,t-1}} + \varepsilon_{it} \quad (19)$$

within each subsample. Each panel of Table 7 focuses on one characteristic and divides the sample into three groups. The coefficient on mandatory contributions (β_3) varies with all of these characteristics though not always in a statistically significant way. The first panel considers median firm age. It shows large and statistically significant point estimates for the effect of required contributions on investment in the youngest and middle-aged firms, with a smaller and not significant effect among the oldest firms. The second panel considers the firm's median S&P credit rating, and tests whether the sensitivity of investment to mandatory contributions is larger for firms with a worse credit rating. Firms with no credit rating or a credit rating worse than BBB+ apparently adjust investment strongly in response to mandatory contributions, whereas firms with credit ratings of A– or above do not display any statistically significant reaction.

The third panel divides the sample along the median four-variable Kaplan-Zingales (KZ) index of financing constraints. This index is formed as in Baker, Stein and Wurgler (2003), who base it on Lamont, Polk and Saa-Requejo (2001) and Kaplan and Zingales (1997):

$$\begin{aligned} KZ_{i,t} &= -1.00 \frac{CashFlow_{i,t}}{A_{i,t-1}} - 39.37 \frac{Dividends_{i,t}}{A_{i,t-1}} - 1.32 \frac{Cash_{i,t}}{A_{i,t-1}} + 3.14 Leverage_{i,t} \\ Leverage_{i,t} &= \frac{Debt_{i,t}}{Debt_{i,t} + Equity_{i,t}} \end{aligned} \quad (20)$$

The purpose of this index is to serve as an objective indicator of the importance of financing constraints for a given observation. The magnitude of the contribution sensitivity estimate in

Table 7 increases with the KZ index, from –0.165 for the lowest (least constrained) to –0.467 for the middle group to –1.364 for the highest group.

There is a question as to whether dividing the sample by age, credit rating, and KZ index is equivalent to sorting on some a priori measure of the magnitude of financing constraints (θ), or to sorting on the amount of external finance that is needed (e). The credit rating is likely to be a relatively pure proxy for θ; the terms of borrowing implied by the credit rating may diverge substantially from the opportunity cost of internal funds. Age is ambiguous: older firms are likely to face lower costs of raising finance externally but they may also be less dependent on external finance. The KZ index is also likely to represent a mix of e and θ. The cash flow, dividend, and balance sheet cash components are directly related to how much cash the company must raise for a given level of investment, but leverage is likely to proxy for the cost of external finance.

The final two panels are meant to divide the sample on measures of e only. Panel 4 divides the sample into two groups based on the level of voluntary contributions. The zero/low group has a statistically significant sensitivity of investment to contributions of –0.958, whereas the high group has a statistically insignificant –0.438. The idea behind this division is that a firm that makes voluntary contributions to its pension plan is probably not constrained, in that it is less likely to need external finance. In a similar vein, the last panel sorts the sample by the percent of observations on the firm for which capital expenditures are greater than cash flow. The sensitivity to mandatory contributions is increasing in this percentage. Firms whose capital expenditures frequently exceed their cash flow have to rely on the capital markets more often. Their investment should therefore be more sensitive to cash shocks. I find that the group of firms whose capital expenditures are greater than cash flow between 37.5% and 100% of the time have a significant and large sensitivity of investment to required contributions. I do not find statistically significant effects in the other groups.[43]

Finally, it is interesting to note that firms with better credit ratings and firms for whom capital expenditures are never greater than cash flow both have *higher* coefficients on the cash flow variable than the other groups. This result illustrates that examining the coefficient on cash flow across groups may not be a useful way to identify financing constraints and is generally supportive of Kaplan and Zingales (1997, 2000) and Cleary (1999). The commonly constructed "investment-cash flow sensitivity" cannot be taken as a measure of the firm's investment

[43] The analysis in Table 7 could be subject to the FHP critique of Poterba (1988), namely that it is difficult to be certain that what appears to be an effect on a component of cash flow is not in fact be differential measurement error in Q across groups. However, the fact that the investment response to mandatory contributions is increasing in many different possible measures of financing constraints makes this a less plausible explanation.

response to a shift in internal financial resources unrelated to investment opportunities.[44] However, the equity dependence analysis of Baker, Stein, and Wurgler (2003), in which the coefficients on Tobin's Q are compared across groups, appears a reasonable use of these sorting techniques. Younger firms, low-rated firms, constrained KZ firms, zero voluntary contribution firms, and firms with capital expenditures usually greater than cash flow have higher coefficients on Tobin's Q.

5. Interpretation and General Equilibrium Considerations

Section 5.1 interprets the results presented above in the context of different models of constrained investment. Section 5.2 considers whether the lost investment might be shifted to future time periods at the same firm. Section 5.3 looks at whether non-pension firms take up the investment that constrained pension sponsors forgo.

5.1 Interpretation of Results and Models of Financing Constraints

The nonparametric evidence presented in Figure 5a shows an upward-sloping relationship between the pension funding status and capital expenditures only in the region where corporate pension plans are underfunded. It is difficult to interpret the different slopes in the underfunded and overfunded regions without the introduction of financing constraints. However, an equally striking aspect of this picture is that average investment is seemingly not sensitive at all to the level of overfunding. There are two possible explanations for this. The first is that the pension funding status is in fact essentially orthogonal to investment opportunities. An implication of this would be that controls for the funding status itself are in fact unnecessary. This explanation violates the common sense notion that weak pension funding is correlated with poor investment opportunities either because of poorly performing equity markets or because weak firms lack the cash to overfund their pension plans. The fact remains that the magnitude of the required contribution effect in Table 2 and Table 6 is smaller in the presence of the funding status controls.

The second explanation is that the funding status *is* correlated with investment opportunities, but actual investment is not sensitive to investment opportunities, perhaps because managers have empire-building tendencies. In this case, the only constraint on investment is an actual cash drain, as in the model of Hart and Moore (1995) where managers undertake investment regardless of its profitability. Malmendier and Tate (2001) show that investment-cash flow sensitivities are correlated with measures of CEO overconfidence, and their results generally suggest that agency problems may explain the sensitivity of investment to internal financial resources. This is a controversial view, with other studies such as Bertrand and Mullainathan

[44] These orderings do not change if the specifications in Table 6 are estimated without mandatory contributions in the equation.

(2003) providing evidence in favor of excessive managerial conservatism. Nevertheless, if the pension funding status is correlated with unobservable investment opportunities, Figure 5a is suggestive of models of overinvestment.

The results would also be consistent with managerial optimism in the sense of Heaton (2002), who shows that optimism may simultaneously cause management to overvalue the firm's investment opportunities and to believe that efficient capital markets undervalue firm securities. In the absence of a cash crunch, managers (over)invest according to their optimistic beliefs. When facing a need to raise more external finance, managers believe that this is too costly and prefer to cut investment.

A related question of interest is whether Figure 5a is consistent with dynamic models of optimal investment. In accordance with the model of Froot, Scharfstein and Stein (1993), it is optimal for firms whose investment opportunities fluctuate with asset markets not to hedge their pension-related risks to fluctuations in those asset markets. But again, if the pension funding status is correlated with investment opportunities, it is remarkable that there is no upward slope of investment with respect to the funding status in the overfunded regions of Figure 5a.

5.2 Is Investment Shifted to Future Time Periods?

The magnitude of the effect of required contributions on investment is more important if it represents permanently forgone investment rather than investment shifted to future time periods. To test whether investment lost from required contributions is shifted to future periods I select a sample of observations which have one and only one large (greater than 0.25% of book assets) required contribution during the sample period and which show a decline in investment in the contribution year relative to the previous year. Figure 6 shows the distribution of investment around the time of these large required pension contributions relative to average investment in the industry-year cell. Industries are assigned based on the Fama and French (1997) 48-industry classification. The industry normalization is done so that the patterns are purged of any industry-related investment trends. The mean, median, 25th percentile, and 75th percentile of the distribution all exhibit a sharp decline in the year of the required contribution and thereafter return to the levels they displayed relative to industry-year average investment in the year before the contribution. It appears that very little investment is actually shifted to future time periods.[45,46]

5.3 General Equilibrium Considerations

[45] In many industries, delays to investment can significantly reduce their profitability to the extent that they may not be worthwhile if they cannot be undertaken at the optimal time.
[46] The results are confirmed with regression analysis: investment does not respond to lagged required contributions in the presence of controls for contemporaneous contributions.

The most facile interpretation of the present results is that firms which sponsor DB plans lower investment in periods when pension contributions are required, and there is no effect on other firms in the economy, so that on aggregate investment is depressed. However, it is possible that rather than depressing investment on a macroeconomic scale, the investment projects that constrained DB sponsors cannot undertake are simply shifted to DB sponsors with healthy pension plans or to sponsors of DC plans.[47] The policy implications of the results found in this paper may be different if the effects are mainly distributional. This is an important general equilibrium question that many empirical papers in economics and finance ignore.[48] Part of the reason for this is that it is difficult to specify a clean test for distributional effects. The firms of interest are often the untreated observations in the sample. These are subject to secular trends and generally serve as controls for the estimation of the treatment effect.

In the present context, one possibility is to examine whether firms that do not sponsor DB plans have higher investment when pension sponsors in their industry have higher mandatory contributions. The drawback of this approach is that it does not allow for a test of whether the investment of DB firms that do not make mandatory contributions actually rises, but given that this group of firms is a control group in estimating the main response, such implications are not testable. If a decline in the investment of DB firms can be taken as given, any rise in investment of non-DB firms can be understood as an offset to the aggregate investment decline caused by pension-related cash requirements.

To test the response of non-pension firms to the required contributions of DB counterparts in their industry, I begin with a sample of Compustat firms in 1990-1998 that do not have DB pension assets.[49] To each firm-year observation I assign an industry classification from the 48-industry delineations of Fama and French (1997). To each observation I also assign a variable designed to proxy for the magnitude of the pension contribution requirement for the DB pension firms in the industry, relative to the size of the non-DB firms in the industry. To build this variable, industry-year total mandatory contributions among the main sample of 8,030 observations are first constructed. This amount is grossed up by the ratio of DB firm assets in that industry-year cell in the Compustat DB sample to the ratio of DB firm assets in that industry-

[47] For example, an effect of -0.60 could represent an investment decline of 0.30 for firms in a given industry that have to make contributions and an investment increase of 0.30 for firms that do not, assuming the asset sizes of these two populations were roughly equal.
[48] I thank Michael Greenstone for encouraging me to consider these issues.
[49] This is effectively column 2.1 of Appendix Table 1.

year cell in the sample of 8,030 firms.[50] Aggregate industry mandatory contributions (*AIMC*) for industry *h* at time *t* are defined as:

$$AIMC_{h,t} = \sum_{j \in h,S} MandatoryContributions_{j,t} \left(\frac{\sum_{j \in h,DB} A_{j,t-1}}{\sum_{j \in h,S} A_{j,t-1}} \right) \tag{21}$$

where *S* is the sample of 8,030 observations and *DB* represents the set of all DB firms in Compustat. The underlying assumption here is that the DB firms in the main sample are representative of the larger universe of Compustat DB firms.

The magnitude of aggregate industry mandatory contributions is important to non-pension firms if it is large relative to their own size. I define the industry pension requirement for the non-DB firms in industry *h* during year *t* as:

$$IndustryPensionRequirement_{h,t} = \frac{AIMC_{h,t}}{\sum_{j \notin DB} A_{j,t-1}}. \tag{22}$$

This variable is the ratio of aggregate industry mandatory contributions to the sum of balance sheet assets for firms in the non-DB sample. The following specification is then estimated to test whether investment by non-pension firms in a given industry-year is higher in the presence of a large industry pension requirement:

$$\frac{CAPX_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 Q_{i.t-1} + \beta_2 \frac{CashFlow_{i,t}}{A_{i,t-1}} + \beta_3 IndustryPensionRequirement_{h(i),t} + \varepsilon_{it} \tag{23}$$

The coefficient β_3 can also be interpreted as the magnitude of the offset to the overall decline in DB firm investment.

Table 8 presents the results. Non-DB firms generally appear to increase investment when the DB pension firms have larger required contributions. The coefficient on the industry pension requirement variable is 0.073 with a standard error of 0.015. Thus, if the DB part of an industry must contribute an amount equal to 1% of the book assets of the non-pension firms in its industry, the non-pension firms in that industry increase capital expenditures by 0.073% of their book assets on average.[51] This implies that 0.073 of the amount of the mandatory contribution is taken up by non-DB firms. If 0.597 of the required contribution comes out of DB firms' capital expenditures, there is an offset on the order of (0.073/0.597) = 12%. In other words, 12% of the

[50] The reason this step is necessary is that the main sample of 8,030 observations does not cover every firm with DB pension assets for reasons described in section 3 and Appendix Table 1.

[51] A contribution of 1% of book assets of non-pension firms could be imagined, for example, in an industry that had an equal asset-weighted composition of pension and non-pension firms, and in which the pension firms had to contribute 1% of book assets as they might in a very bad year such as 2003.

depressing effect of mandatory contributions on DB firms' capital investment is offset by higher investment among non-DB firms in the same industry. Furthermore, although the point estimate of the response is not monotonically decreasing across the KZ groups, the estimates of the response in the lowest two groups are not statistically distinguishable from one another, and the response in the most constrained group is not statistically different from zero.

These results are evidence of distributional effects, suggesting that the macroeconomic magnitude of the reduction in investment as a result of required pension contributions is not as large as the very substantial decline in aggregate US capital expenditures that would be implied by Table 2. Non-pension firms undertake some of the investment projects that pension firms leave on the table, offsetting the aggregate effect by around 12%.

6. Conclusions and Directions for Further Work

In this paper I exploit an asymmetry in the funding rules for US pension plans in order to identify a relationship between capital expenditures and internal financial resources. Firms are required to contribute to underfunded plans, but are restricted in their ability to contribute to overfunded plans. Therefore, the extent of underfunding exerts an immediate influence on internal financial resources through mandatory pension contributions, while overfunding does not. The fact that required contributions are a discontinuous function of the funding status allows for a clean identification of the effect of required contributions on investment, as investment opportunities can be controlled for with Tobin's Q, cash flow, and the funding status itself.

Using a nine-year panel of 1,500 firms, I find that pension sponsors decrease spending on capital expenditures in response to a reduction in internal resources caused by required pension contributions. The central point estimate of 0.60 is quite large compared to the standard large-sample sensitivity of investment to cash flow, which is usually on the order of 0.10-0.15. The estimates in this study carry through to a variety of functional forms, including two-stage estimation using pension funding status or mandatory contributions as instruments. Firms that appear more constrained or more dependent on external finance based on observable margins also exhibit a greater investment sensitivity to required pension contributions. The intertemporal investment pattern of a sample of firms that have one year of large contribution requirements suggests that little of the forgone investment is shifted to future periods.

An interesting direction for further work would be to examine the effects that shifts to internal financial resources have on stock prices, particularly across different levels of corporate governance. If markets rationally believe that on the margin this cash would have gone largely to empire-building projects with zero or negative net present value, a company's market value would not be expected to decline as much in response to a cash hit compared to a situation where

they believed the cash was necessary to finance positive NPV projects. Tests of market responses to such phenomena would shed light on the relative importance of agency stories of overinvestment versus asymmetric information and underinvestment.

Another important path for further investigation is the analysis of what kinds of projects are cut as a result of cash constraints. Gertner, Powers, and Scharfstein (2002) show that spin-offs tend to cut investment in low Q industries and increase investment in high Q industries, raising the possibility of cross-subsidization of investment within firms. A deeper investigation of the properties of the internal segments for which investment declines in response to external cash needs could elucidate the internal capital allocation process.

The empirical investment sensitivity estimates in this paper are meant to be generalizable to all cash shocks and not limited to pension funding shocks. However, they also have important implications for investment in the current pension funding crisis. Taking my central point estimate of a $0.60 decrease in capital expenditures per dollar of mandatory contributions, the effect of the PBGC-estimated aggregate mandatory contributions under the present law would be to reduce total capital expenditures by $39.3bn and $75.2bn in 2003 and 2004 respectively.[52] Compared to aggregate capital expenditures of $618.7bn for DB pension firms in 2002, this would represent a substantial decrease in investment by DB pension sponsors on the order of 6.4% and 12.2% respectively for 2003 and 2004. If total 2002 economy-wide private nonresidential fixed investment of $1.1 trillion is taken as a benchmark, it would be lower by 3.6% and 6.8% respectively in 2003 and 2004 without congressional relief.

An important question is the extent to which firms that do not sponsor defined benefit pension plans take up the investment projects that constrained pension sponsors are unable to finance. The evidence suggests that firms which do not sponsor defined benefit pension plans undertake approximately 12% of the capital investment that pension sponsors in their industry leave on the table when required contributions are high. This makes the aggregate negative effect on investment 12% smaller than it otherwise would have been. Contribution requirements in the presence of financing constraints may therefore have important effects both on aggregate investment and on the distribution of investment across firms.

[52] These estimates are based on investment falling by 60% of the PBGC estimates of required contributions, which are $65.5 billion of contributions in 2003 and $125.3 billion in 2004. See Pension Benefit Guaranty Corporation (2003).

Data Appendix: Construction of Estimated Required Contributions for 1999-2003

In addition to the 1990-1998 sample, estimates of mandatory contributions for the beginning of fiscal years 1999-2003 are also calculated for Figure 3. This requires a number of approximation steps as Compustat data must be used to approximate the IRS 5500 variables that are not available for these years.

Compustat pension data, suffer from several drawbacks. First, the data arrive aggregated to the firm level, so intra-firm variation in the funding status of plans is lost. Second, pension liabilities are calculated using the projected benefit obligation (PBO) method, in which prospective salary increases are taken into account when computing the current obligation. The required deficit reduction contribution is determined based on the ABO funding status. Third, domestic and international pension assets of US corporations are aggregated into one pension asset variable and one pension liability variable. This is problematic because mandatory contributions are determined on a plan-by-plan basis for domestic pension plans only and using the ABO liability measures from the IRS 5500 filings. Fourth, companies do not generally report the "normal cost" in their annual reports and SEC filings. The "service cost," a component of the income statement pension expense, must be used to approximate the normal cost.

To construct funding status variables for 1999-2003 that are comparable to the 1990-1998 variables, I first determine a ratio of IRS 5500 (domestic) pension assets to Compustat (global) pension assets for firm-year observations in the main 1990-1998 sample. I calculate the median of this value within each firm. I then exclude all firms for whom this median asset ratio is less than 0.90, on the grounds that there is too much error from the inclusion of foreign pension assets. A similar ratio is then calculated of IRS (ABO) to Compustat (PBO) liabilities. The median of this liability ratio for 1990-1998 is calculated within each firm and the ratio is applied to the Compustat PBO from 1999-2003 to derive estimated IRS ABO liabilities. The median of the asset ratio is similarly applied to the Compustat assets to derive estimated IRS assets. A drawback of this procedure is that it only includes for 1999-2003 firms that existed in 1991-1998 and survived into 1999 or beyond. Note that in years 1999-2003, firms are either underfunded or overfunded, as variation in within-firm-year funding status is lost by this construction.

The other ingredient necessary to derive mandatory contributions for 1999-2003 is an estimate of the normal cost. The relationship between the service cost (which is reported in Compustat) and the normal cost (which is not) is generally determined by the cost accounting method. I take a simplified approach and calculate within-firm median ratios of normal cost to service cost. I apply these ratios to the service cost for 1999-2003 to derive an estimate of the normal cost.

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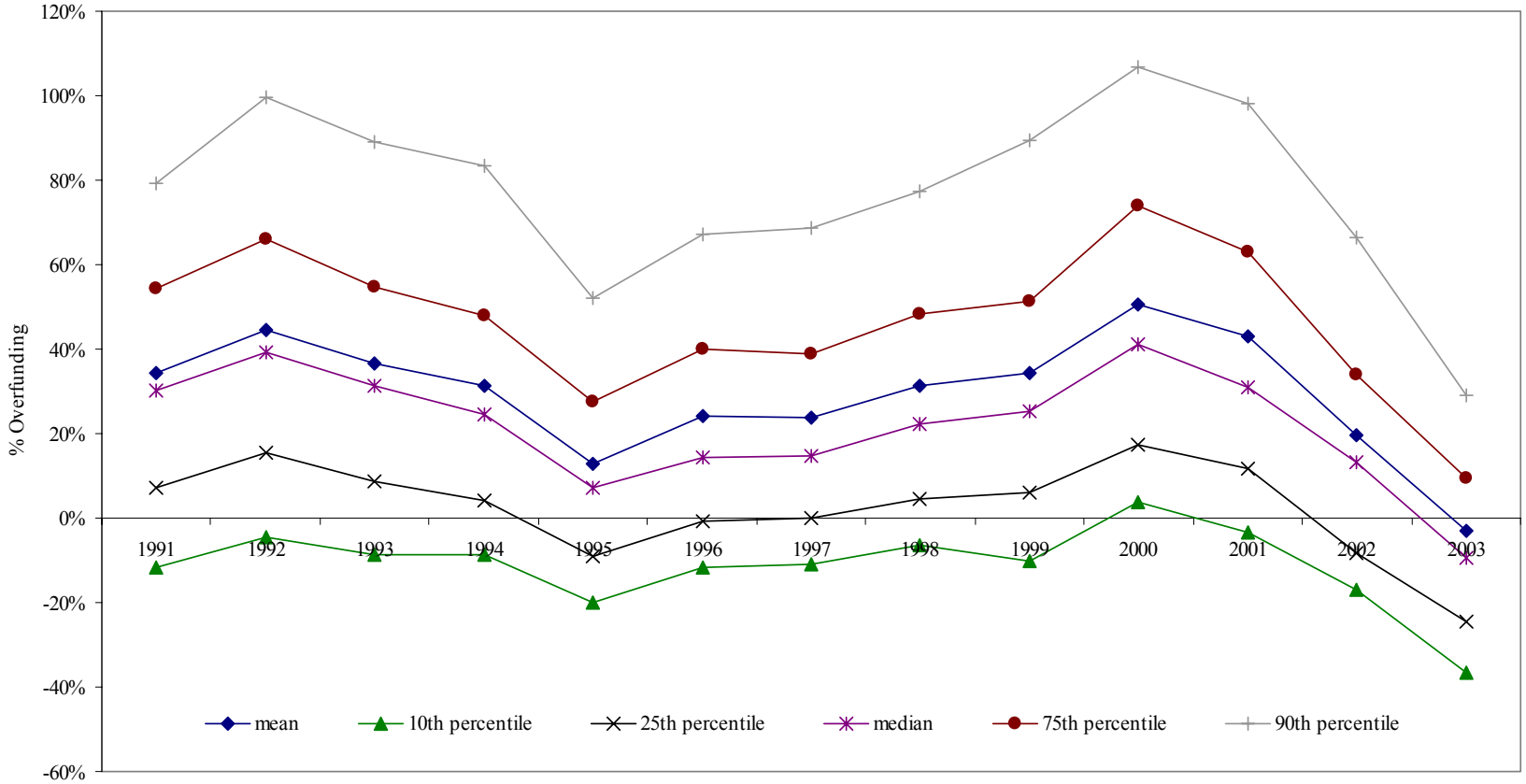
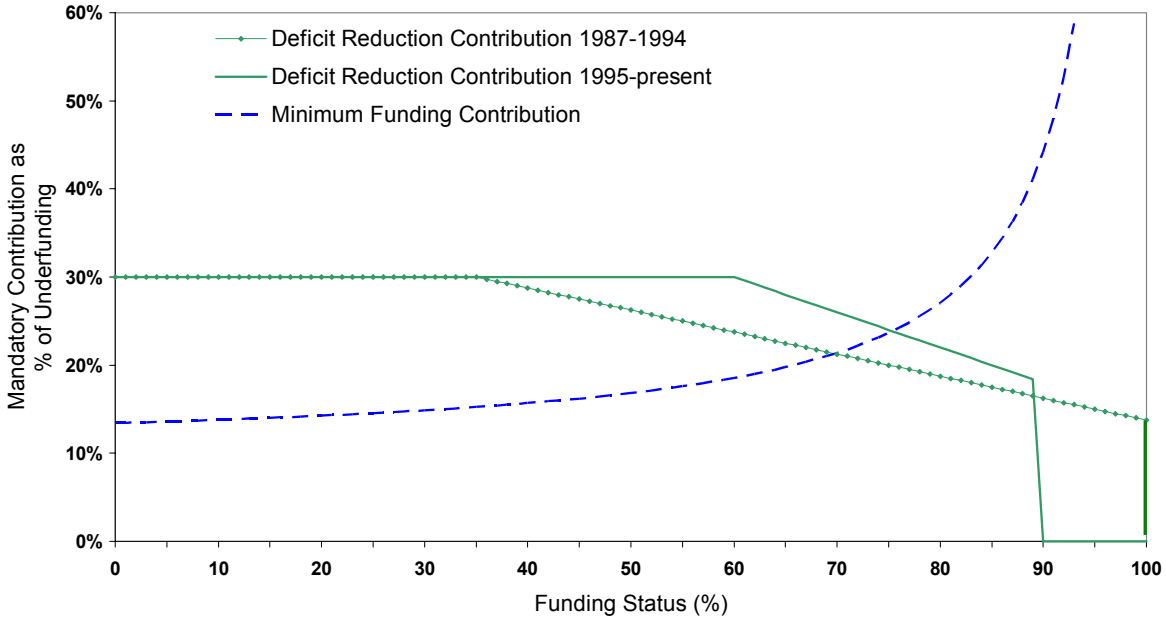
Figure 1: Distribution of Beginning-of-Year Funding Status for Compustat Firms (1991-2003)



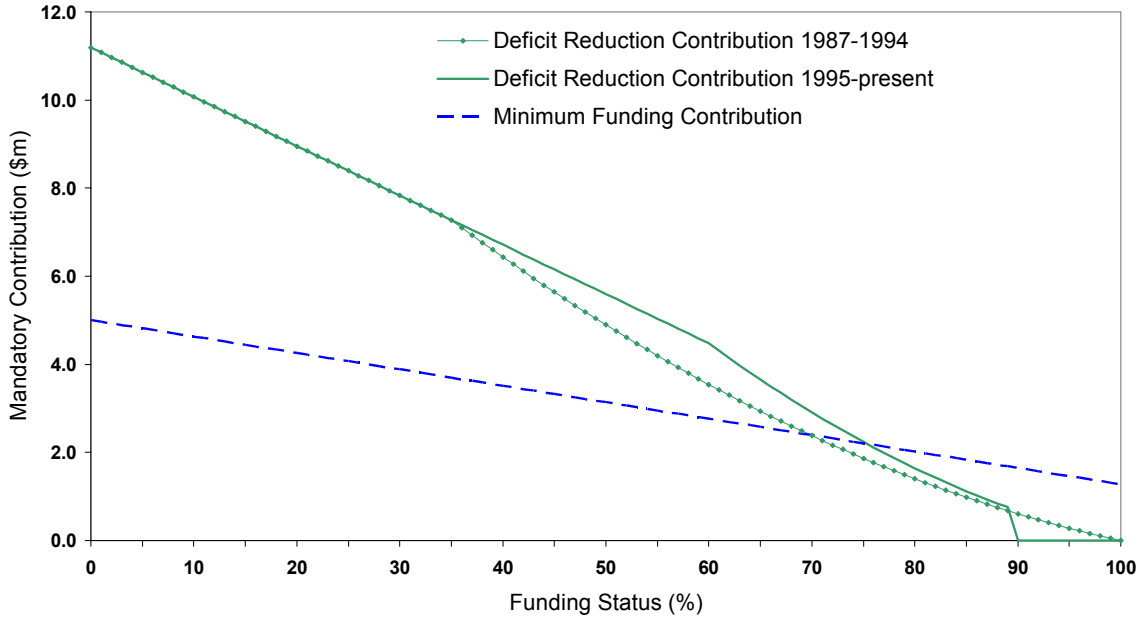
This figure shows the distribution of aggregate firm-level pension funding status as of the start of the fiscal year in the main sample for years 1991-2003. The funding status is defined as pension assets minus pension liabilities divided by pension liabilities. The data are from the annual filings of companies in the Compustat database, and therefore are already aggregated to the firm level with liabilities on a projected benefit obligation (PBO) basis.

Figure 2a: Mandatory Pension Contribution as a Percentage of Underfunding



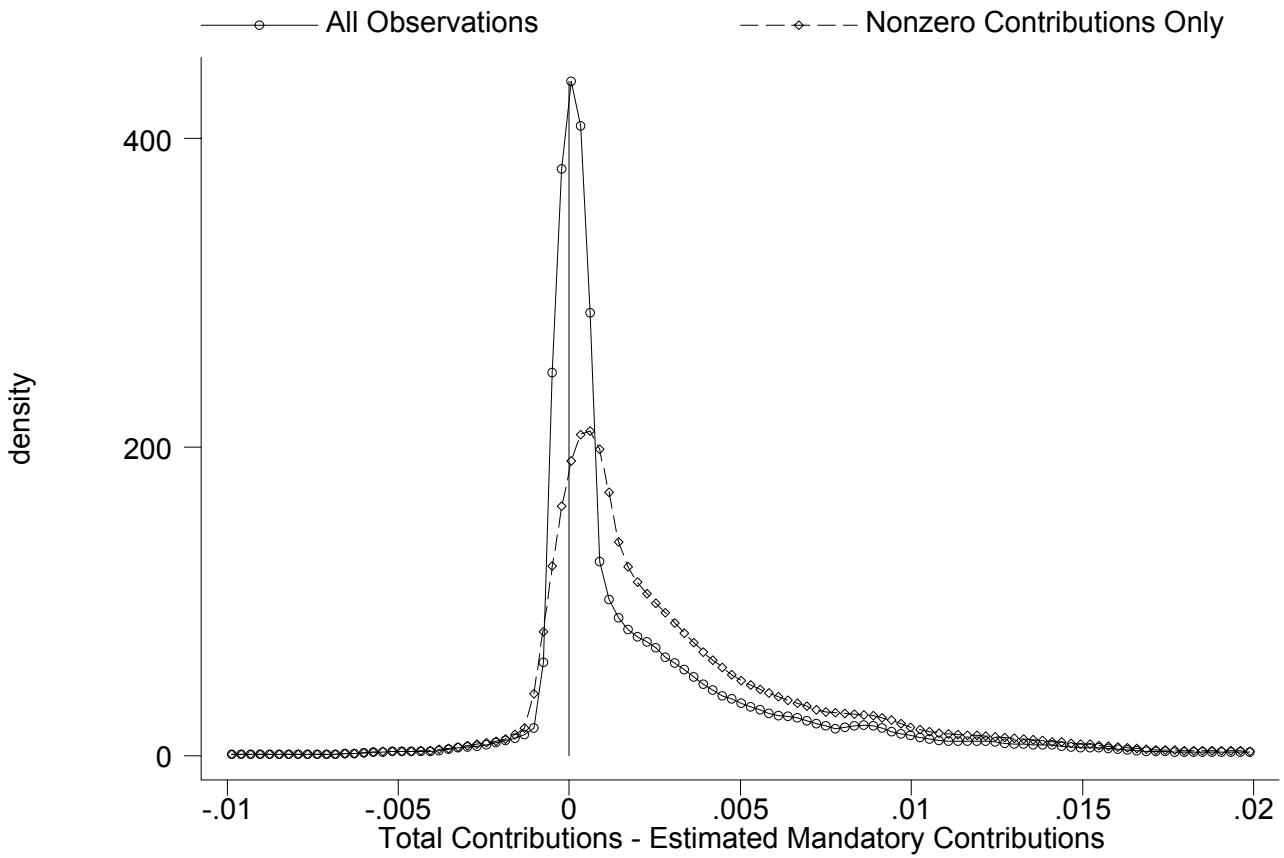
A firm's required pension contribution is the maximum of two components: the minimum funding contribution and the deficit reduction contribution. The deficit reduction contribution as a percentage of firm funding is given by min{0.30,[0.30 – 0.25*(funding status – 0.35)]} for 1987-1994 and min{0.30,[0.30 – 0.40*(funding status – 0.60)]} for 1995 and later. The minimum funding contribution is defined as the "normal cost" plus 10% of the underfunding. This graph assumes that the firm has no prior credits, and that the ERISA and current liability funding statuses are equal. The normal cost differs on a firm-by-firm basis depending on the accounting cost method and the rate of liability accrual. The dashed line in this graph represents the minimum funding contribution for a firm with liabilities of $37.3m and a normal cost of $1.3m, as these are the sample means.

Figure 2b: Mandatory Pension Contribution in Dollars



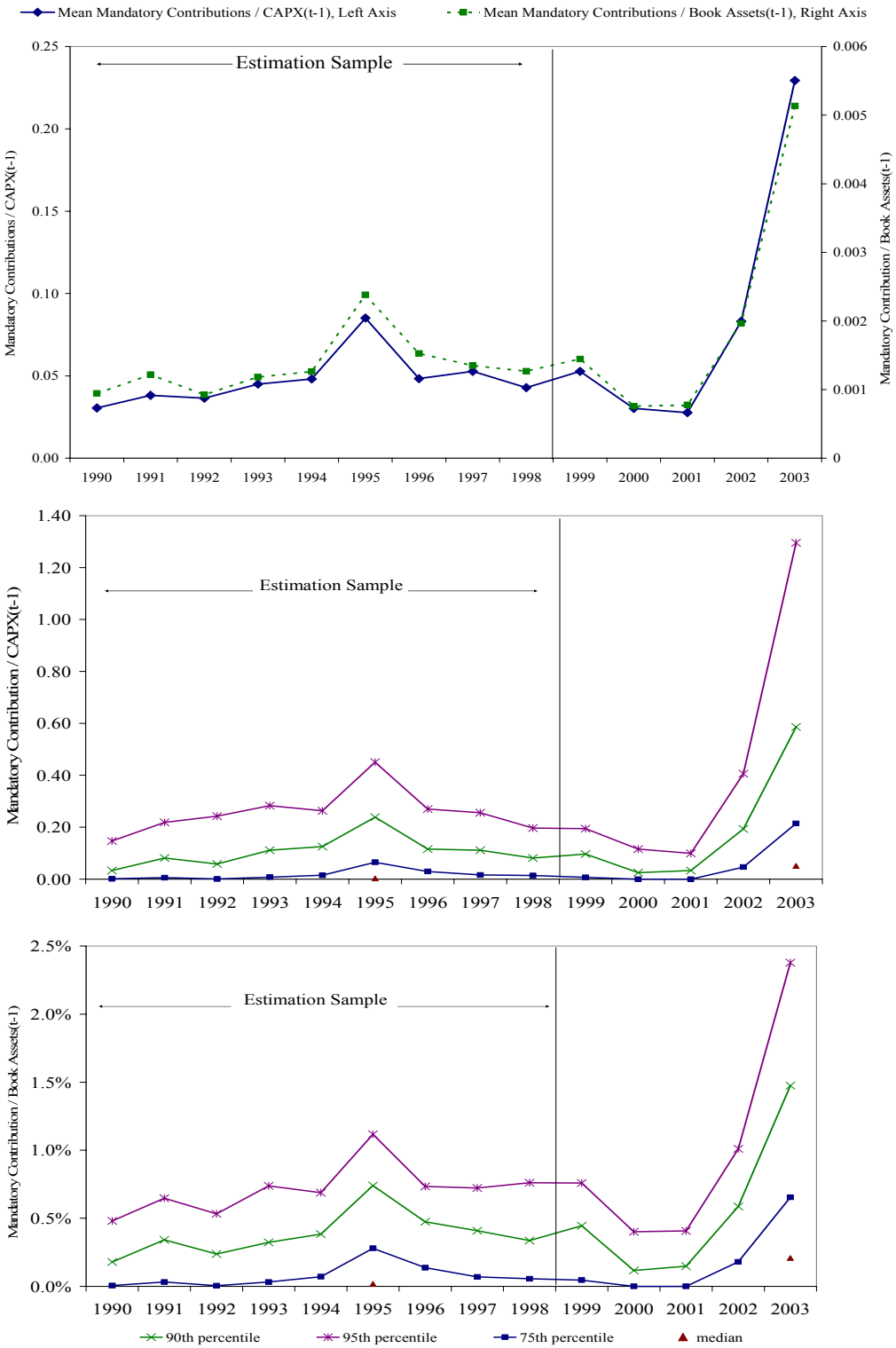
This figure expresses the same rules as Figure 2a but in dollar terms, using the same assumptions as Figure 2a.

Figure 3: Probability Density of the Difference Between Actual Total Contributions and Estimated Mandatory Contributions



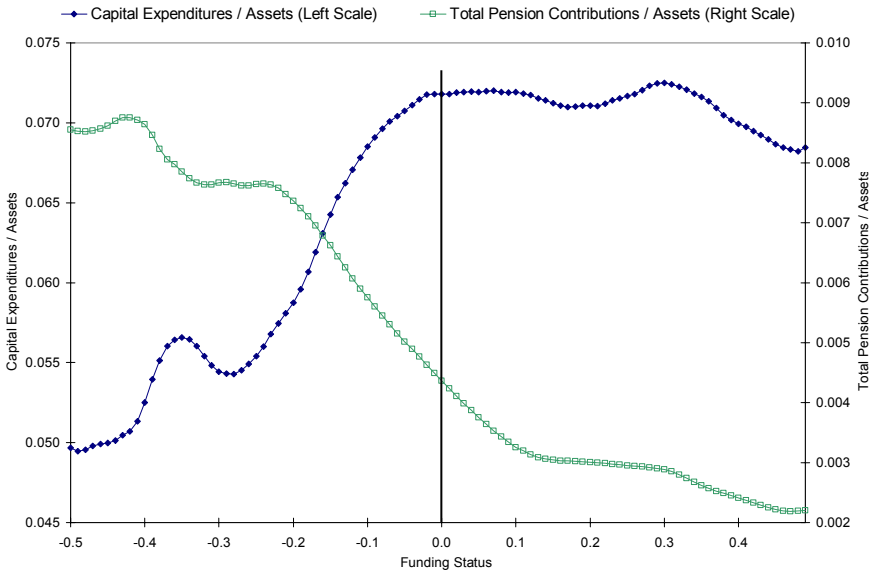
Kernel density estimation of the difference between reported total contributions and estimated mandatory contributions is performed using the Epanechnikov kernel. The bandwidth is given by the optimality formula of Silverman (1986), $h = min\left(\sigma_x, \frac{p75(x) - p25(x)}{1.349}\right) * 0.9n^{-1/5}$.

Figure 4: Estimated Mandatory Contributions



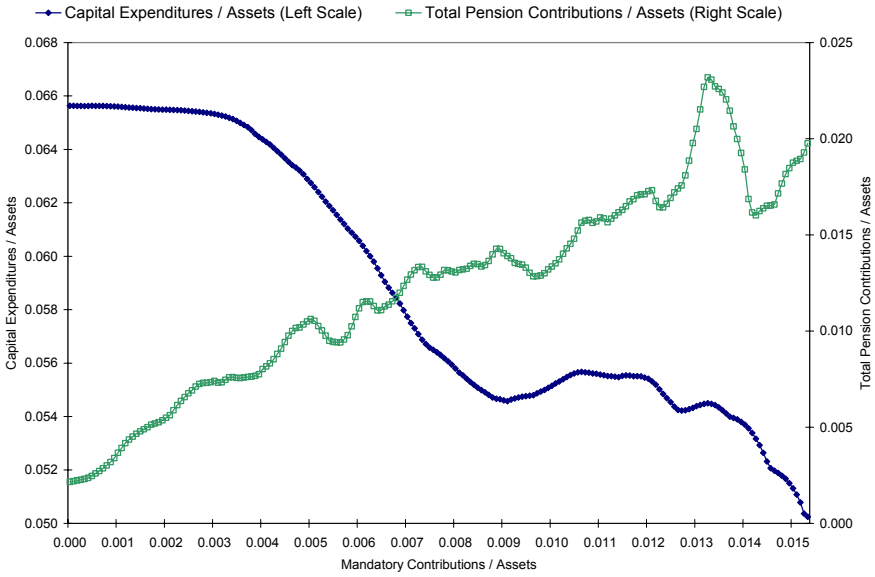
Estimates of the mandatory contribution for the period 1990-1998 are calculated based on data from the IRS 5500 plan-level filings aggregated to the firm level; these estimates are used in the regression analysis. Simulated values of mandatory contributions for 1999-2003 are based on Compustat data for firms that are also in the IRS 5500 sample for the earlier period and are corrected for the differences between the two reporting regimes (see appendix).

Figure 5a: Kernel Regressions of Capital Expenditures and Total Pension Contributions on Funding Status (1990-1998)



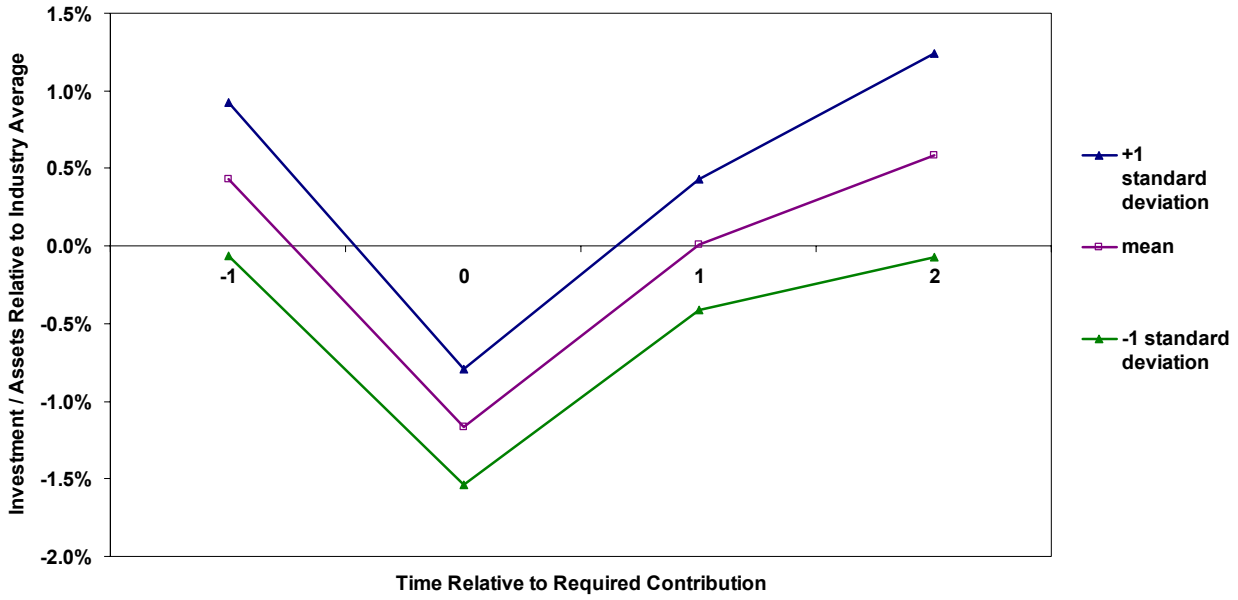
Kernel regression estimation was performed on the pooled data using the Epanechnikov kernel and bandwidths of 0.1. The funding status is aggregated to the firm level. The lighter line shows the nonparametric relationship between the funding status and pension contributions. The darker line shows the nonparametric relationship between the funding status and capital expenditures.

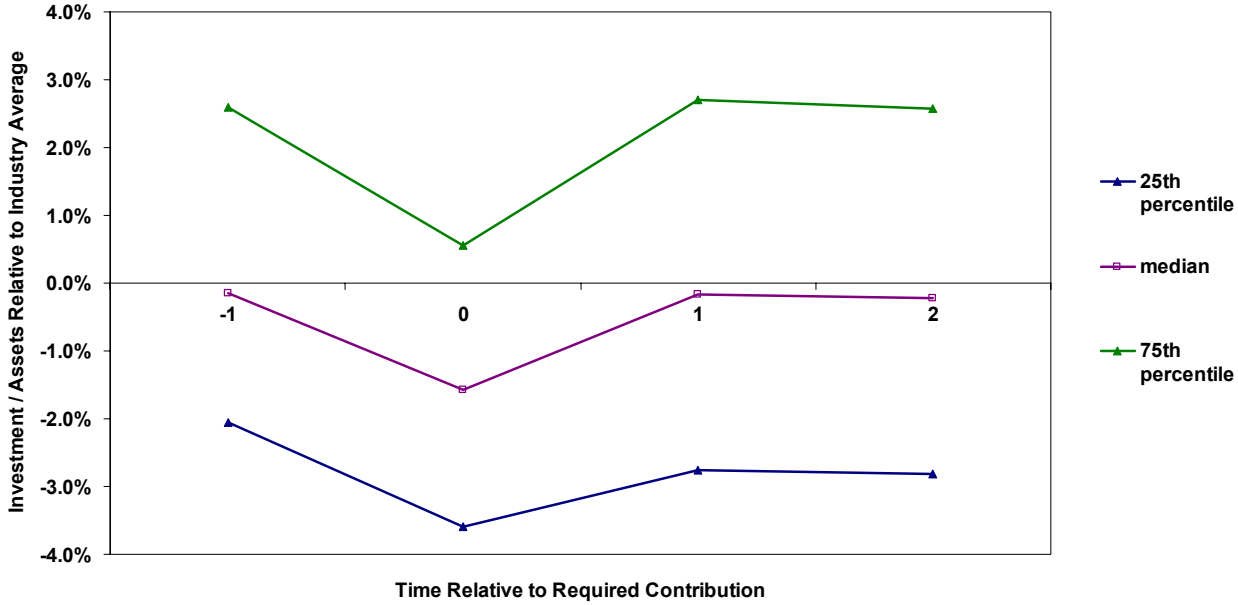
Figure 5b: Kernel Regressions of Capital Expenditures and Total Pension Contributions on Mandatory Contributions (1990-1998)



Kernel regression estimation was performed on the pooled data using the Epanechnikov kernel and bandwidths of 0.005 and 0.0005 for capital expenditures and contributions respectively. The lighter line plots the nonparametric relationship between mandatory contributions and total pension contributions. The darker line plots the relationship between mandatory contributions and investment.

Figure 6: Investment Around the Time of Large Required Pension Contributions





These figures show the distribution of investment relative to the average investment within each firm's industry-year cell, around the time of large required contributions. The figures are drawn for a sample of 94 firms which satisfy two criteria: 1.) the firm a required contribution of at least 0.25% of assets in one and only one year during the period 1990-1998; 2.) the firm shows a decline in investment in that year relative to the previous year. The vertical axes show the difference between the firm's investment scaled by book assets and industry investment scaled by book assets in the observation year. The 48 industry categorization of Fama and French (1997) is used for this purpose.

Table 1: Summary Statistics

Years 1990-1998, Observations = 8030, Firms = 1522

	Mean	Median	Standard Deviation	Nonzero Observations	Percentiles, Conditional on Nonzero				
					10th	25th	50th	75th	90th
Capital Expenditures / Assets$_{-1}$	0.069	0.058	0.053	8030	0.018	0.034	0.058	0.089	0.131
Cash Flow / Assets$_{-1}$	0.096	0.096	0.077	8030	0.014	0.058	0.096	0.140	0.182
Non-Pension Cash Flow / Assets$_{-1}$	0.099	0.099	0.077	8030	0.017	0.061	0.099	0.143	0.187
Total Pension Contributions / Assets$_{-1}$	0.003	0.001	0.006	5582	0.000	0.001	0.003	0.007	0.013
Pension Expense / Assets$_{-1}$	0.007	0.005	0.008	8006	0.000	0.002	0.005	0.010	0.017
Total US Pension Assets / Assets$_{-1}$	0.137	0.087	0.157	8030	0.010	0.033	0.087	0.181	0.329
Total US Pension Liabilities (ABO) / Assets$_{-1}$	0.112	0.067	0.134	8030	0.009	0.028	0.067	0.140	0.270
Total Global Pension Assets / Assets$_{-1}$	0.172	0.117	0.174	7766	0.024	0.060	0.121	0.235	0.409
Underfunding / Assets$_{-1}$	0.004	0.000	0.014	3021	0.000	0.001	0.003	0.011	0.032
Overfunding / Assets$_{-1}$	0.030	0.011	0.046	6624	0.001	0.005	0.018	0.046	0.095
Tobin's Q (beginning of year)	1.479	1.256	0.707	8030	0.901	1.034	1.256	1.681	2.339
Firm Age (years)	26.3	28.0	14.1	8030	5	13	28	39	44
Assets ($m)	3643	737	8669	8030	76	209	737	2697	9220
Mandatory Contributions / Assets$_{-1}$	0.001	0.000	0.003	2380	0.000	0.000	0.001	0.003	0.008
Mandatory Contributions / Cash Flow$_{-1}$	0.009	0.000	0.043	2380	0.000	0.001	0.008	0.031	0.099
Mandatory Contributions / Capital Expenditures$_{-1}$	0.033	0.000	0.132	2380	0.000	0.004	0.199	0.084	0.289

This table presents summary statistics for the main sample of 8030 firm-year observations. For inclusion in the sample, a firm-year observation must be found in both Compustat and the IRS 5500 database of US defined benefit plans with more than 100 participants — see Appendix Table 1 for sample construction. All variables are winsorized at the 1st and 99th percentiles of their distributions. Most variables are as of fiscal year end, scaled by beginning of year balance sheet assets at book value (data6). *Capital Expenditures* are from the firm's statement of cash flows (data128). *Cash Flow* equals non-pension cash flow minus total pension contributions. *Non-Pension Cash Flow* equals net income plus depreciation and amortization plus the accounting definition of the pension expense (data14 + data18 + data43); this is essentially the same measure as used by Kaplan and Zingales (1997) and Baker, Stein and Wurgler (2003) but the accounting definition of pension expense is added back as a non-cash component of reported earnings. *Total Pension Contributions* are reported on the IRS 5500 forms at the plan level and in this study are aggregated to the firm level. *Total US Pension Assets* are the current value of pension assets as of the beginning of the year from the IRS 5500s. *Total US Pension liabilities (ABO)* are accumulated benefit obligation current liabilities from Schedule B of the IRS 5500s. For years 1991-1994 this variable is the OBRA87 liability and for years 1995-1998 it is the RPA94 liability. *Underfunding* (*Overfunding*) equals the market value of assets in underfunded (overfunded) plans minus the current liabilities of underfunded plans. *Tobin's Q* is the market value of equity (data199*data25) plus book assets (data6) minus the book value of common equity including deferred taxes (data60 + data74) over assets, as in Baker, Stein and Wurgler (2003). *Mandatory Contributions* are the estimated mandatory component of contributions as described in section 3.

Table 2: Panel Regressions of Capital Expenditures on Pension and Non-Pension Cash Flows (1990-1998)

	Dependent Variable: $CAPX_{it}$ (Capital Expenditures)								
	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
Contributions (Mandatory)$_{i,t}$ / $A_{i,t-1}$			-0.830***			-0.607**			-0.597**
			(0.289)			(0.296)			(0.300)
Contributions (Total)$_{i,t}$ / $A_{i,t-1}$		0.109			0.309*			0.334**	
		(0.162)			(0.166)			(0.167)	
Cash Flow$_{i,t}$ / $A_{i,t-1}$	0.111***								
	(0.012)								
Non-Pension Cash Flow$_{i,t}$ / $A_{i,t-1}$		0.111***	0.112***	0.112***	0.110***	0.111***	0.111***	0.110***	0.110***
		(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
$Q_{i,t-1}$	0.019***	0.019***	0.019***	0.019***	0.019***	0.019***	0.019***	0.019***	0.019***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Underfunding$_{i,t-1}$ / $A_{i,t-1}$				-0.164**	-0.221***	-0.075	-0.141	-0.273	-0.040
				(0.065)	(0.070)	(0.066)	(0.250)	(0.262)	(0.256)
Overfunding$_{i,t-1}$ / $A_{i,t-1}$				0.020	0.025	0.021	0.150*	0.163*	0.148*
				(0.025)	(0.024)	(0.024)	(0.088)	(0.088)	(0.088)
Powers of Underfunding$_{i,t-1}$ / $A_{i,t-1}$ and Overfunding$_{i,t-1}$ / $A_{i,t-1}$	0	0	0	1	1	1	1,2,3	1,2,3	1,2,3
Observations	8030	8030	8030	8030	8030	8030	8030	8030	8030
Number of Clusters or Groups	1522	1522	1522	1522	1522	1522	1522	1522	1522
Adjusted R-Squared	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68

Standard errors are in parentheses. *** significant at 1%; ** significant at 5%; * significant at 10%.
All models contain firm fixed effects and year fixed effects. Standard errors are heteroskedasticity-robust and clustered by firm.
Each column presents estimation of a regression of the form:

$$\frac{CAPX_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_{21} Q_{i,t-1} + \beta_{22} \frac{NonPensionCashFlow_{i,t}}{A_{i,t-1}} + \beta_{23} \frac{Contributions_{i,t}}{A_{i,t-1}} + X'\Gamma + \upsilon_{i,t}$$

Variables are scaled by beginning-of-year balance sheet assets ($A_{i,t-1}$). The coefficient of interest is the effect of (mandatory) contributions on investment. In specifications (1a), (2a) and (3a), non-pension cash flow and contributions are aggregated into one cash flow variable. In (1b), (2b) and (3b), the contributions variable is total contributions. In (1c), (2c) and (3c) it is mandatory contributions. In specifications (2a)-(2c), the funding status is controlled for linearly by including the extent of underfunding and overfunding as explanatory variables, and these coefficients are shown. In the specifications (3a)-(3c), additional controls are added for powers of the funding status variables, i.e. (Underfunding$_{i,t-1}$ / $A_{i,t-1}$)^2, (Underfunding$_{i,t-1}$ / $A_{i,t-1}$)^3, (Overfunding$_{i,t-1}$ / $A_{i,t-1}$)^2, and (Underfunding$_{i,t-1}$ / $A_{i,t-1}$)^3; coefficients of these powers are not shown.

Table 3: Alternative Specifications for Capital Expenditure Responses

Dependent Variable: $CAPX_{it}$ (Capital Expenditures)						
	Alternate Panel Specifications			Alternate Funding Status Controls		
Contributions (Mandatory)$_{i,t}$ / $A_{i,t-1}$	-0.616**	-0.473*	-0.496*	-0.669**	-0.705***	-0.571*
	(0.295)	(0.276)	(0.258)	(0.268)	(0.263)	(0.344)
Contributions (Total)$_{i,t}$ / $A_{i,t-1}$						
Cash Flow$_{i,t}$ / $A_{i,t-1}$						
Non-Pension Cash Flow$_{i,t}$ / $A_{i,t-1}$	0.100**	0.145**	0.086**	0.113***	0.107***	0.110***
	(0.012)	(0.008)	(0.008)	(0.012)	(0.012)	(0.012)
$Q_{i,t-1}$	0.018**	0.013**	0.020**	0.019***	0.018***	0.019***
	(0.002)	(0.001)	(0.001)	(0.002)	0.002	(0.002)
Underfunding$_{i,t}$ / $A_{i,t-1}$	-0.046	-0.111*	0.041			0.596*
	(0.066)	(0.061)	(0.061)			(0.320)
Overfunding$_{i,t}$ / $A_{i,t-1}$	0.033	-0.008	0.028			0.178*
	(0.025)	(0.016)	(0.020)			(0.095)
Underfunding (%)				-0.003	-0.003	-0.061
				(0.002)	(0.002)	(0.049)
Overfunding (%)				-0.000	-0.001	0.009
				(0.002)	(0.002)	(0.008)
Pension Assets$_{i,t}$ / $A_{i,t-1}$					0.031***	
					(0.009)	
Estimation Method	FE(+)	RE	FD	FE	FE	FE
Observations	8030	8030	6688	8030	8030	8030
Number of Clusters or Groups	1522	1522	—	1522	1522	1522
Adjusted R-Squared	0.62	—	0.07	0.61	0.61	0.61
R-Squared (Within)	0.18	0.10	—	0.10	0.10	0.10

Standard errors are in parentheses. *** significant at 1%; ** significant at 5%; * significant at 10%.
FE(+) = firm and industry-by-year fixed effects, RE = Random Effects, FD = First Difference
In fixed effects specifications, standard errors are heteroskedasticity-robust and clustered by firm.
The left panel investigates the sensitivity of the results to different panel estimation methods. The right panel considers the sensitivity of the results to different funding status controls. *Underfunding$_{i,t}$ / $A_{i,t-1}$* equals assets in underfunded plans minus liabilities in underfunded plans scaled by book assets. *Overfunding$_{i,t}$ / $A_{i,t-1}$* equals assets in overfunded plans minus liabilities of overfunded plans scaled by book assets. *Underfunding (%)* equals assets in underfunded plans over liabilities in underfunded plans. *Overfunding (%)* equals assets in overfunded plans over liabilities in overfunded plans.

Table 4: Required Contributions and Uses of Funds

	Explanatory Variables				
Dependent Variable	Cash Flow	$Q_{i,t-1}$	Underfunding	Overfunding	Mandatory Contributions
Panel 1: Effects of Mandatory Contributions on Outcomes, with Funding Status Controls					
CAPX	0.111***	0.019***	-0.075	0.021	-0.607**
	(0.012)	(0.002)	(0.066)	(0.024)	(0.296)
R&D	-0.004	0.003***	-0.031	0.011	0.133
	(0.006)	(0.001)	(0.023)	(0.009)	(0.116)
Acquisitions	0.114***	0.011***	-0.031	0.135**	-0.166
	(0.025)	(0.004)	(0.127)	(0.056)	(0.465)
Dividends	0.015***	0.004***	-0.028	0.017**	0.022
	(0.003)	(0.001)	(0.021)	(0.008)	(0.067)
Repurchases	0.014*	0.007***	-0.118**	0.017	0.160
	(0.008)	(0.002)	(0.058)	(0.020)	(0.296)
Δ Book Equity	1.117***	0.014**	0.115	0.053	0.487
	(0.038)	(0.005)	(0.264)	(0.068)	(1.142)
Δ Retained Earnings	0.944***	0.001	0.153	0.003	-0.714
	(0.022)	(0.003)	(0.214)	(0.041)	(0.731)
Δ Outstanding Debt	-0.009	0.041***	0.083	0.444***	0.076
	(0.074)	(0.009)	(0.474)	(0.127)	(1.856)
Δ Trade Credit	-0.125***	-0.004	-0.017	-0.092***	0.012
	(0.022)	(0.003)	(0.124)	(0.034)	(0.557)
Panel 2: Regressions of Funding Status Variables Only on Outcomes					
CAPX	0.112***	0.019***	-0.164**	0.020	
	(0.012)	(0.002)	(0.065)	(0.024)	
R&D	-0.004	0.003***	-0.011	0.012	
	(0.006)	(0.001)	(0.020)	(0.009)	
Acquisitions	0.114***	0.011***	-0.055	0.135**	
	(0.025)	(0.004)	(0.114)	(0.056)	
Dividends	0.015***	0.004***	-0.025	0.017**	
	(0.003)	(0.001)	(0.016)	(0.008)	
Repurchases	0.014*	0.007***	-0.094**	0.017	
	(0.008)	(0.002)	(0.037)	(0.020)	
Δ Book Equity	1.117***	0.014**	0.186	0.053	
	(0.038)	(0.005)	(0.204)	(0.068)	
Δ Retained Earnings	0.944***	0.001	0.047	0.003	
	(0.022)	(0.003)	(0.176)	(0.041)	
Δ Outstanding Debt	-0.009	0.041***	0.094	0.444***	
	(0.074)	(0.009)	(0.383)	(0.127)	
Δ Trade Credit	-0.125***	-0.004	-0.015	-0.092***	
	(0.022)	(0.003)	(0.089)	(0.034)	

Standard errors are in parentheses. *** significant at 1%; ** significant at 5%; * significant at 10%.
Standard errors are heteroskedasticity-robust and clustered by firm.
This table estimates the main specifications form Table 2 on different dependent variables: capital expenditures, research and development, acquisitions, dividends, repurchases, equity issuance (change in book equity and change in retained earnings), debt issuance (change in outstanding debt), and change in trade credit. All variables are scaled by beginning-of-year assets. Book equity includes deferred taxes, i.e. (data60 + data74). Retained earnings is from company financial statements (data36). Outstanding debt is total assets at book value minus book equity. Trade credit is accounts payable (data70) minus accounts receivable (data2).

Table 5: Behavior of Mandatory and Voluntary Pension Contributions (1990-1998)

	Dependent variable: mandatory contributions				*Dependent variable: voluntary contributions*			
	(1a)	(1b)	(1c)	(1d)	(2a)	(2b)	(2c)	(2d)
$Q_{i,t-1}$	0.0001	0.0001	0.0000	-0.0002**	-0.0003	-0.0003	-0.0003	-0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0001)
Non-Pension Cash $Flow_{i,t}$ / $A_{i,t-1}$	0.0003	0.0002	0.0000	0.0002	0.0042***	0.0034***	0.0045***	0.0135***
	(0.0009)	(0.0010)	(0.0006)	(0.0007)	(0.0011)	(0.0013)	(0.0011)	(0.0010)
$Underfunding_{i,t-1}$ / $A_{i,t-1}$			0.147***	0.214***			0.033***	0.057***
			(0.011)	(0.003)			(0.012)	(0.005)
$Overfunding_{i,t-1}$ / $A_{i,t-1}$			0.001	-0.017***			-0.014***	-0.021***
			(0.002)	(0.001)			(0.003)	(0.002)
Mandatory $Contributions_{i,t}$ / $A_{i,t-1}$					0.005			
					(0.054)			
Mandatory $Contributions_{i,t-1}$ / $A_{i,t-1}$		0.223***				0.156***		
		(0.063)				(0.054)		
Voluntary $Contributions_{i,t-1}$ / $A_{i,t-1}$		0.026				0.120***		
		(0.019)				(0.033)		
Specification	FE	FE	FE	Tobit	FE	FE	FE	Tobit
Observations	8030	6032	8030	8030	8030	6032	8030	8030
Number of Firms	1583	1375	1583	1583	1583	1375	1583	1583
Adjusted R-squared	0.66	0.68	0.80	—	0.58	0.62	0.58	—

Standard errors are in parentheses. *** significant at 1%; ** significant at 5%; * significant at 10%.
FE stands for Fixed Effects. All fixed effects models contain firm fixed effects and year fixed effects. Standard errors are heteroskedasticity-robust and clustered by firm.
The fixed effects specifications in this table reports results of regressions of the form:

$$\frac{Contributions_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_{11} Q_{i,t-1} + \beta_{12} \frac{NonPensionCashFlow_{i,t}}{A_{i,t-1}} + X'\Gamma + \upsilon_{i,t}$$

where X is a vector of control variables that may include lagged contributions variables. The dependent variable is mandatory contributions in the left panel and voluntary contributions in the right panel. See footnote to Table 1 for descriptions of the variable construction.
The Tobit specifications (1d) and (2d) estimate a similar expression taking account of censoring at zero, but without firm effects.

Table 6: Two-Stage Regressions of Capital Expenditures on Pension and Non-Pension Cash Flows (1990-1998)

	2nd Stage Dependent Variable: $CAPX_{i,t}$ (Capital Expenditures)					
	(1a)	(1b)	(1c)	(1d)	(2a)	(2b)
Contributions (Total)$_{i,t}$ / $A_{i,t-1}$	-0.852 ***	-0.782 **	-0.934 ***	-0.905 ***		
	(0.231)	(0.375)	(0.273)	(0.290)		
Non-Pension Cash Flow$_{i,t}$ / $A_{i,t-1}$	0.116 ***	0.115 ***	0.116 ***	0.116 ***		
	(0.009)	(0.009)	(0.009)	(0.009)		
Cash Flow$_{i,t}$ / $A_{i,t-1}$					0.700 ***	0.589 *
					(0.257)	(0.342)
Underfunding$_{i,t-1}$ / $A_{i,t-1}$		-0.022				-0.062
		(0.086)				(0.083)
Overfunding$_{i,t-1}$ / $A_{i,t-1}$		0.008		0.007		-0.047
		(0.021)		(0.021)		(0.053)
$Q_{i,t-1}$	0.018 ***	0.019 ***	0.018 ***	0.018 ***	-0.008	-0.003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.012)	(0.016)
	1st Stage Dependent Variable: Pension Contributions (Total)$_{i,t}$				*Cash Flow$_{i,t}$*	
Contributions (Mandatory)$_{i,t}$ / $A_{i,t-1}$	0.974 ***	0.777 ***			-1.157 ***	-1.037 ***
	(0.022)	(0.029)			(0.333)	(0.430)
Non-Pension Cash Flow$_{i,t}$ / $A_{i,t-1}$	0.005 ***	0.005 ***	0.005 ***	0.005 ***		
	(0.001)	(0.001)	(0.001)	(0.001)		
Underfunding$_{i,t-1}$ / $A_{i,t-1}$		0.067 ***	0.182 ***	0.182 ***		-0.001
		(0.007)	(0.006)	(0.006)		(0.100)
Overfunding$_{i,t-1}$ / $A_{i,t-1}$		-0.016 ***	-0.015 ***	-0.015 ***		0.137 ***
		(0.002)	(0.002)	(0.002)		(0.030)
$Q_{i,t-1}$	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0003 ***	0.045 ***	0.045 ***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.002)	(0.002)
Observations	8030	8030	8030	8030	8030	8030
Number of Clusters or Firm Groups	1522	1522	1522	1522	1522	1522
Within R-squared First Stage	0.25	0.27	0.19	0.19	0.11	0.11
Within R-squared Second Stage	0.09	0.09	0.09	0.09	0.13	0.13

Standard errors are in parentheses. *** significant at 1%; ** significant at 5%; * significant at 10%.
All models contain firm fixed effects and year fixed effects. Standard errors are heteroskedasticity-robust and clustered by firm.

In specifications (1a)-(1d), the instrumented variable is pension contributions:

$$\frac{CAPX_{i,t}}{A_{i,t-1}} = \alpha_{2i} + \alpha_{2t} + \beta_{21} Q_{i,t-1} + \beta_{22} \frac{NonPensionCashFlow_{i,t}}{A_{i,t-1}} + \beta_{23} \frac{Contribs_{i,t}}{A_{i,t-1}} + X'\Gamma_2 + \varepsilon_{i,t}$$

$$\frac{Contribs_{i,t}}{A_{i,t-1}} = \alpha_{1i} + \alpha_{1t} + \beta_{11} Q_{i,t-1} + \beta_{12} \frac{NonPensionCashFlow_{i,t}}{A_{i,t-1}} + \beta_{13} \frac{Z_{i,t}}{A_{i,t-1}} + X'\Gamma_1 + \upsilon_{i,t}$$

where $Z_{i,t}$ is an instrument or set of instruments that shifts the firm's pension-adjusted cash flow. In (1a) and (1b), $Z_{i,t}$ is mandatory contributions. In column (1c), $Z_{i,t}$ is consists of the two funding status variables. In column (1d), $Z_{i,t}$ is underfunding, with overfunding entering X as a control. In specifications (2a) and (2b), the instrumented variable is pension adjusted cash flow:

$$\frac{CAPX_{i,t}}{A_{i,t-1}} = \alpha_{2i} + \alpha_{2t} + \beta_{21} Q_{i,t-1} + \beta_{22} \frac{CashFlow_{i,t}}{A_{i,t-1}} + X'\Gamma_2 + \varepsilon_{i,t}$$

$$\frac{CashFlow_{i,t}}{A_{i,t-1}} = \alpha_{1i} + \alpha_{1t} + \beta_{11} Q_{i,t-1} + \beta_{12} \frac{Z_{i,t}}{A_{i,t-1}} + X'\Gamma_1 + \upsilon_{i,t}$$

where $Z_{i,t}$ is again an instrument that shifts the firm's pension-adjusted cash flow. In both (2a) and (2b), $Z_{i,t}$ is mandatory contributions

Table 7: Mandatory Contributions and Capital Expenditures by Characteristics

				Explanatory Variables					
				Cash Flow		$Q_{i,t-1}$		Mandatory Contributions	
Dependent Variable: $CAPX_{i,t} / A_{i,t-1}$	Count	Min	Max	coeff	t-stat	coeff	t-stat	coeff	t-stat
Panel 1: Sorting by Median Firm Age									
Age (Youngest)	2741	1	20	0.127	6.34	0.023	6.43	-0.954	-2.32
Age (Middle)	2790	21	34	0.095	4.93	0.019	4.44	-1.087	-2.15
Age (Oldest)	2499	35	48+	0.118	5.51	0.011	3.27	-0.578	-0.98
Panel 2: Sorting by Median S&P Credit Rating									
No S&P Credit Rating	3597	—	—	0.090	5.95	0.019	5.37	-0.893	-2.30
S&P Credit Rating (Low)	2942	D	BBB+	0.118	5.82	0.025	5.89	-0.825	-1.77
S&P Credit Rating (High)	1491	A-	AAA	0.214	5.38	0.011	3.38	0.639	0.50
Panel 3: Sorting by Median Kaplan-Zingales Index of Financing Constraint									
Kaplan-Zingales (Lowest)	2679	-4.2	0.0	0.118	5.602	0.010	4.055	-0.165	-0.30
Kaplan-Zingales (Middle)	2678	0.0	0.9	0.133	5.817	0.028	4.799	-0.467	-1.21
Kaplan-Zingales (Highest)	2673	0.9	4.3	0.086	4.882	0.032	6.281	-1.364	-3.16
Panel 4: Sorting by Median Voluntary Contributions									
Voluntary Contributions (Zero/Low)	6608	0.0000	0.0025	0.104	7.627	0.021	7.480	-0.958	-2.12
Voluntary Contributions (High)	1422	0.0025	0.0314	0.140	3.795	0.018	3.424	-0.438	-0.68
Panel 5: Sorting by % of Firm Observations for which CAPX > Cash Flow									
Never	2905	0.000	0.000	0.215	10.01	0.006	2.87	-0.340	-1.12
Less than 1/3 of years	2627	0.111	0.333	0.094	5.79	0.022	5.93	-0.420	-0.84
More than 1/3 of years	2498	0.375	1.000	0.091	4.88	0.030	5.46	-1.523	-3.18

Standard errors are heteroskedasticity-robust and clustered by firm.
This table reports results of regressions of the form:

$$\frac{CAPX_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_{21} Q_{i,t-1} + \beta_{22} \frac{NonPensionCashFlow_{i,t}}{A_{i,t-1}} + \beta_{23} \frac{MandatoryContributions_{i,t}}{A_{i,t-1}} + \upsilon_{i,t}$$

with the results sorted by hypothesized *a priori* indicators of financing constraints. A firm's age is defined as the number of years since its IPO year and is approximated as in Baker, Stein and Wurlger (2003) as the number of years the firm is included in Compustat. The S&P Credit Rating is the S&P long-term domestic issuer credit rating (data280). Voluntary contributions are defined as the difference between actual contributions and mandatory contributions. The Kaplan-Zingales index is the four-variable construction of Baker, Stein and Wurgler (2003) based on Lamont, Polk and Saa-Requejo (2001) and Kaplan and Zingales (1997):

$$KZ_{i,t} = -1.00 \frac{CashFlow_{i,t}}{A_{i,t-1}} - 39.37 \frac{Dividends_{i,t}}{A_{i,t-1}} - 1.32 \frac{Cash_{i,t}}{A_{i,t-1}} + 3.14 Leverage_{i,t}$$

Table 8: Investment Response of Non-DB Firms to Mandatory Contributions of Pension Firms in the Same Industry

	Dependent Variable: Capital Expenditures$_{i,t}$ / A$_{i,t-1}$			
	All Non-DB Firms	*Sorted by Median KZ Index*		
		Low	*Middle*	*High*
Cash Flow$_{i,t}$ / A$_{i,t-1}$	0.075***	0.084***	0.064***	0.077***
	(0.010)	(0.012)	(0.014)	(0.019)
Q$_{i,t-1}$	0.005***	0.000	0.009***	0.009***
	(0.001)	(0.001)	(0.002)	(0.002)
Industry Pension Requirement$_{i,t}$	0.073***	0.068***	0.117***	-0.019
	(0.015)	(0.023)	(0.033)	(0.110)
Observations	46848	15597	15582	15564

*** significant at 1%; ** significant at 5%; * significant at 10%.
Standard errors are heteroskedasticity-robust and are clustered by industry.
For firm *i* at time *t* in industry *h*, the following specification is estimated:

$$\frac{CAPX_{i,t}}{A_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 Q_{i,t-1} + \beta_2 \frac{CashFlow_{i,t}}{A_{i,t-1}} + \beta_3 IndustryPensionRequirement_{h(i),t} + \varepsilon_{it}$$

The analysis uses the 48-industry division of Fama and French (1997). The *Industry Pension Requirement* is constructed as the sum of estimated mandatory pension contributions at the industry-year level divided by the lagged balance sheet assets of non-pension assets in that industry-year cell. This variable is a measure of the magnitude of industry pension contributions relative to the size of the industry's non-pension firms. The results in this table report regressions on the sample of Compustat firms that do not have any defined benefit pension assets (data287 and data296 both equal zero). This is the sample in column (2.1) of Appendix Table 1.

Appendix Table 1: Composition of Sample

	Start	Non-DB versus DB Pension Samples			Match	Finish
Year	(1)	(2.1)	(2.2)	(2.3)	(3) / (3-Plan)	(4)
1990	6421	4265	2156	1943	1240 [2810]	746
1991	6483	4311	2172	1942	1619 [3380]	947
1992	6662	4462	2200	1963	1499 [2951]	883
1993	7079	4849	2230	1984	1612 [3103]	997
1994	7474	5201	2273	2019	1660 [3188]	1031
1995	7684	5419	2265	1972	1009 [1866]	660
1996	8403	6080	2323	2017	1355 [2562]	918
1997	8511	6247	2264	1964	1394 [2431]	919
1998	8151	6014	2137	1876	1446 [2588]	949
	66868	46848	20020	17680	12834 [24879]	8050
Capital Expenditures in Compustat	•	•	•	•	•	•
Never has DB	•	•				
Has DB plan						
any year	•		•			
that year	•			•	•	•
Matched to IRS					•	•
All Variables						•

This table contains observation counts by fiscal year for the sample at different stages of construction. The starting sample (1) is all Compustat firms with non-missing capital expenditures. Columns (2.1)-(2.3) show the sample counts for the firms that never have DB pension assets, for firms that have DB assets in at least one year, and for firms that have DB assets in the given year respectively. Column (3) is the sample that matches with the IRS 5500 dataset. The number in brackets in column (3) is the number of *plan* observations from the tax filings that were collapsed to obtain the number of firm observations in each row of column (3). The match was done sequentially by CUSIP, name, and EIN. The majority of DB plans are sponsored by companies that are not publicly traded and hence a large part of the IRS 5500 database is not used in this study. Firms with multiple plans are retained in the IRS sample, and indeed are useful sources of identification in cases where a single firm has both overfunded and underfunded plans. However, if a firm has multiple plans with different fiscal year-end months (e.g. one plan with a fiscal year ending in September and another plan with a fiscal year ending in December) all the firm's plans are dropped from the sample. Requirements for the final sample are: pension expense on an accounting basis is reported in Compustat, pension fiscal year must match firm fiscal year within one month, requisite Compustat data must exist to compute capital expenditures, Q, cash flow, and assets, and IRS 5500 filing complete enough to determine the funding status.