## Empirical Approaches to the Investment-Cash Problem in Other Studies

1. "investment-cash flow sensitivities"

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

- Fazzari, Hubbard and Petersen (1988) sort on *a priori* measures of constraint (dividends) and interpret $\beta_2$
- Kaplan and Zingales (1997) show that $\beta_2$ is not higher for firms that truly appear constrained
- Alti (2003) and Moyen (2004) use simulated data to derive expected relationships between *I* and *CF*
- Many potential problems: measurement error in *Q* (Poterba (1988), Erickson and Whited (2000)), average vs. marginal *Q,* failure of underlying assumptions in dynamic optimization.

2. Observe responses to cash windfalls/hits in very small, specialized samples
   - Blanchard, Lopez-de-Silanes, and Shleifer (1994) look at eleven lawsuit outcomes
   - Lamont (1997), oil prices and non-oil segments of 26 oil companies over a couple years
3. Other Work
   - Almeida, Campello and Weisbach (2004) on the cash flow sensitivity of cash and value of liquidity management

# Rauh (2004): Idea

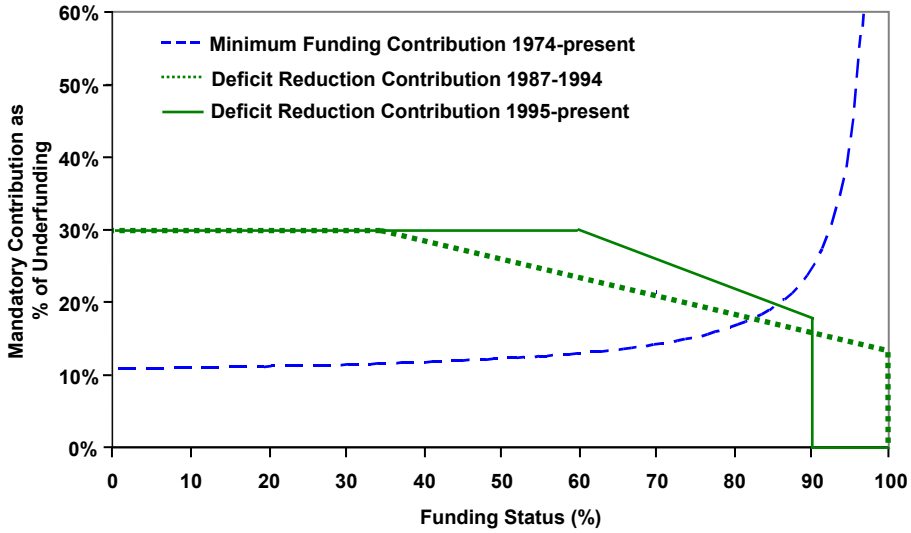
Use non-linearities in pension fund contributions.

- Firms that sponsor defined benefit (DB) pension plans must make financial contributions to their pension funds:
  - If underfunded, mandatory contributions.
  - If overfunded, contributions only up to a limit.
- Contributions affect internal financial resources.
- If a firm is financially constrained, contributions thus affect ability to invest
- Required contributions more likely to be exogenous relative to investment opportunities.

# Rauh (2004): Idea

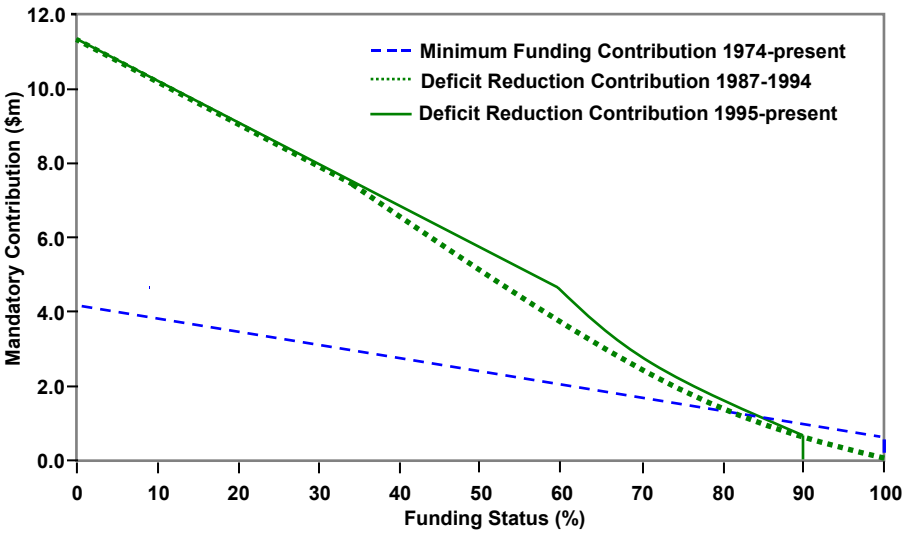
- Only underfunded plans must contribute
- Required contribution is the maximum of two components:
  1. Minimum Financing Contribution
     - Standard based on ERISA
     - Includes fixed cost that is related to the amount of newly accrued benefits, plus a variable component
     - Allows offset with prior credits
  2. Deficit Reduction ("catch-up") Contribution
     - a percentage of the level of underfunding that varies with the funding status

# Mandatory Contributions (%)



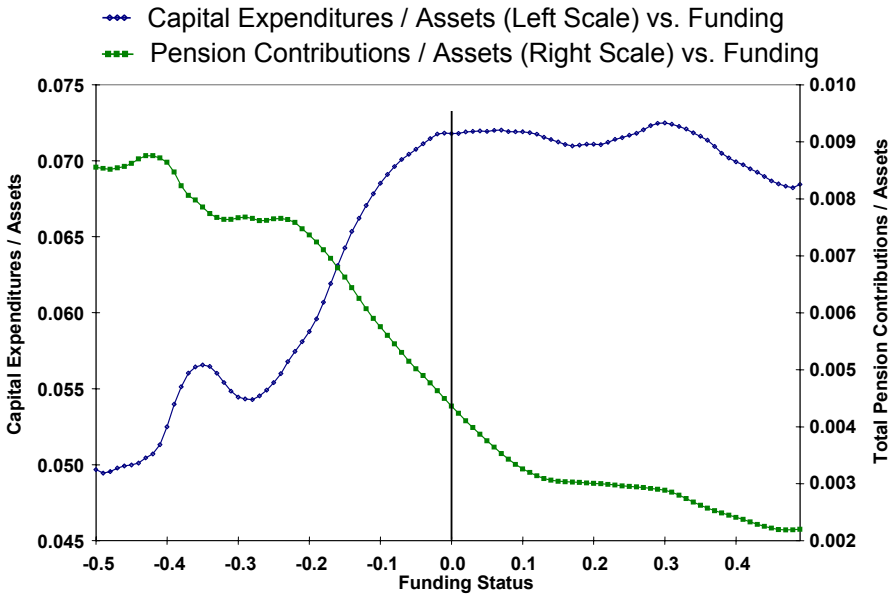

Minimum funding contribution drawn for a firm with sample mean characteristics: liabilities of $37.3m, a normal cost of $1.3m, and prior credits of $0.5m.

# Mandatory Contributions ($m)

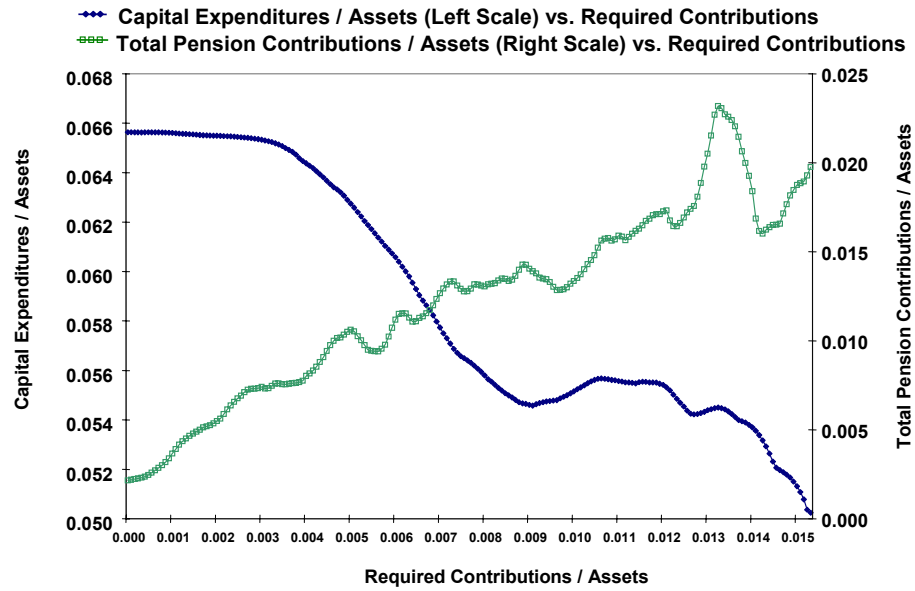



Minimum funding contribution drawn for a firm with sample mean characteristics: liabilities of $37.3m and a normal cost of $1.3m, assuming prior credits of $0.5m.

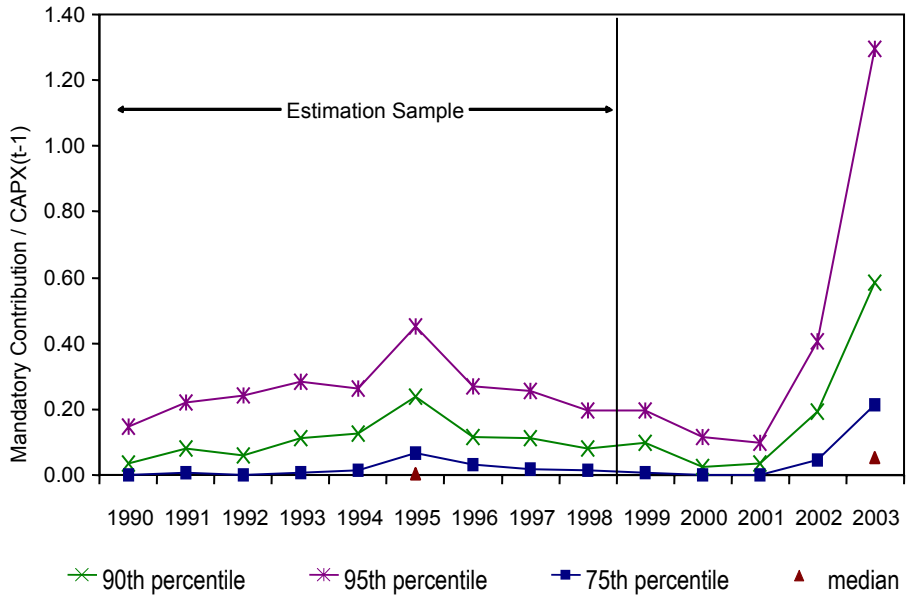
# Nonparametric Evidence (A)



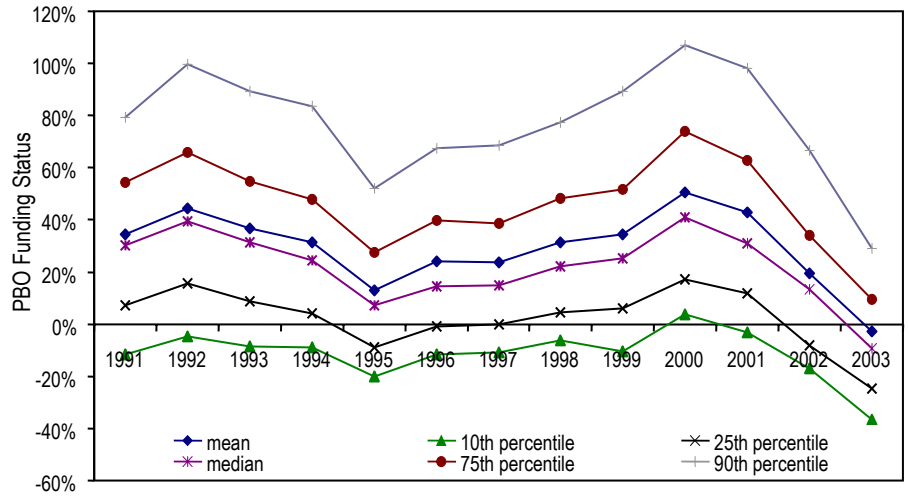

# Nonparametric Evidence (B)



## Distribution of Mandatory Contributions




## Distribution of Beginning-of-Year Funding Status for Compustat Firms (1991-2003)




Funding status = (Pension Assets – PBO Liabilities) / PBO Liabilities

# Description of Sample

- Pension data from IRS 5500 filings matched to Compustat financial data
  - IRS plan level data allows separate accounting for underfunded and overfunded plans
  - Key inputs include the relevant funding status and the new benefits accrued during the year
- Yields an unbalanced panel of 8030 observations on 1522 firms
  - Compustat universe would consist of 66868 observations
  - Restrict to firms with defined-benefits assets reported in financial statements → 17680 observations
  - Match results in 8030 observations

# Financial Summary Statistics

| | Mean | Median | Standard Deviation | Percentiles 25th | 50th | 75th |
|---|---|---|---|---|---|---|
| *Matched Sample (N = 8030)* | | | | | | |
| Capital Expenditures / $Assets_{-1}$ | 0.069 | 0.058 | 0.053 | 0.034 | 0.058 | 0.089 |
| Cash Flow / $Assets_{-1}$ | 0.096 | 0.096 | 0.077 | 0.058 | 0.096 | 0.140 |
| Non-Pension Cash Flow / $Assets_{-1}$ | 0.099 | 0.099 | 0.077 | 0.061 | 0.099 | 0.143 |
| Total Pension Contributions / $Assets_{-1}$ | 0.003 | 0.001 | 0.006 | 0.001 | 0.003 | 0.007 |
| Tobin's Q (beginning of year) | 1.479 | 1.256 | 0.707 | 1.034 | 1.256 | 1.681 |
| Firm Age (years) | 26.3 | 28.0 | 14.1 | 13 | 28.0 | 39 |
| Assets ($m) | 3643 | 737 | 8669 | 209 | 737 | 2697 |
| *Compustat Universe (N = 66868)* | | | | | | |
| Capital Expenditures / $Assets_{-1}$ | 0.083 | 0.048 | 0.117 | 0.024 | 0.052 | 0.101 |
| Cash Flow / $Assets_{-1}$ | 0.038 | 0.073 | 0.214 | -0.003 | 0.072 | 0.138 |
| Tobin's Q (beginning of year) | 1.735 | 1.223 | 1.589 | 0.918 | 1.228 | 1.923 |
| Firm Age (years) | 12.9 | 8.0 | 11.9 | 4.0 | 8.0 | 19.0 |
| Assets ($m) | 1484 | 91 | 5351 | 19 | 91 | 522 |

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

$$CashFlow \equiv \underset{data18}{NetIncome} + \underset{data14}{DA} + \underset{data43}{PensionExpense} - \underset{IRS5500s}{Contributions}$$

# Pension Summary Statistics

| | Nonzero Observations | Conditional Percentiles | | | | |
|---|---|---|---|---|---|---|
| | | 10th | 25th | 50th | 75th | 90th |
| *Matched Sample (N = 8030)* | | | | | | |
| US Pension Assets / $A_{-1}$ | 8030 | 0.010 | 0.033 | 0.087 | 0.181 | 0.329 |
| US Pension Liabilities (ABO) / $A_{-1}$ | 8030 | 0.009 | 0.028 | 0.067 | 0.140 | 0.270 |
| Global Pension Assets / $A_{-1}$ | 7766 | 0.024 | 0.060 | 0.121 | 0.235 | 0.409 |
| Underfunding / $A_{-1}$ | 3021 | 0.000 | 0.001 | 0.003 | 0.011 | 0.032 |
| Overfunding / $A_{-1}$ | 6624 | 0.001 | 0.005 | 0.018 | 0.046 | 0.095 |
| Mandatory Contributions / $A_{-1}$ | 2380 | 0.0000 | 0.0002 | 0.0010 | 0.0031 | 0.0082 |
| Mandatory Contributions / Cash $Flow_{-1}$ | 2380 | 0.000 | 0.001 | 0.008 | 0.031 | 0.099 |
| Mandatory Contributions / $CAPX_{-1}$ | 2380 | 0.000 | 0.004 | 0.199 | 0.084 | 0.289 |

Notes:

- Approximately 15% of sample observations have mandatory contributions > 20% of capital expenditures
- 50% of firms have a required contribution in some year, 25% of firms have only one or two years of required contributions

# Baseline Parametric Specification

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

- $NonPensionCF \equiv \underset{data18}{NetIncome} + \underset{data14}{DA} + \underset{data43}{PensionExpense}$
- $Z_{i,t}$ is a shifter of cash flow
  - *e.g.* mandatory contributions
  - nonlinear, non-differentiable, and discontinuous function of funding status
- $X$ is an additional vector of controls
  - can include funding status itself and its powers
  - identification off of discontinuity in $Z$
- $\alpha_i$ and $\alpha_t$ allow for firm and year fixed effects

# Fixed Effects Regressions of Capital Expenditures on Cash Flows (OF/UF control)

| *Dependent Variable: $CAPX_{it}$ (Capital Expenditures) / $A_{i,t-1}$* | | | |
|---|---|---|---|
| Contributions (Mandatory)$_{i,t}$ / $A_{i,t-1}$ | | | -0.607 ** |
| | | | (0.296) |
| Contributions (Total)$_{i,t}$ / $A_{i,t-1}$ | | 0.309 * | |
| | | (0.166) | |
| Non-Pension Cash Flow$_{i,t}$ / $A_{i,t-1}$ | 0.112 *** | 0.110 *** | 0.111 *** |
| | (0.012) | (0.012) | (0.012) |
| $Q_{i,t-1}$ | 0.019 *** | 0.019 *** | 0.019 *** |
| | (0.002) | (0.002) | (0.002) |
| Underfunding$_{i,t-1}$ / $A_{i,t-1}$ | -0.164 ** | -0.221 *** | -0.075 |
| | (0.065) | (0.070) | (0.066) |
| Overfunding$_{i,t-1}$ / $A_{i,t-1}$ | 0.020 | 0.025 | 0.021 |
| | (0.025) | (0.024) | (0.024) |
| Observations | 8030 | 8030 | 8030 |
| Number of Firms | 1522 | 1522 | 1522 |
| Adjusted R-Squared | 0.68 | 0.68 | 0.68 |

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

# Fixed Effects Regressions of Capital Expenditures on Cash Flows (power of OF/UF)

| *Dependent Variable: $CAPX_{it}$ (Capital Expenditures) / $A_{i,t-1}$* | | | |
|---|---|---|---|
| Contributions (Mandatory)$_{i,t}$ / $A_{i,t-1}$ | | | -0.597 ** |
| | | | (0.300) |
| Contributions (Total)$_{i,t}$ / $A_{i,t-1}$ | | 0.334 ** | |
| | | 0.167 | |
| Non-Pension Cash Flow$_{i,t}$ / $A_{i,t-1}$ | 0.111 *** | 0.110 *** | 0.110 *** |
| | (0.012) | (0.012) | (0.012) |
| $Q_{i,t-1}$ | 0.019 *** | 0.019 *** | 0.019 *** |
| | (0.002) | (0.002) | (0.002) |
| *Controls* | | | |
| Powers of Funding Variables | 3 | 3 | 3 |
| Observations | 8030 | 8030 | 8030 |
| Number of Firms | 1522 | 1522 | 1522 |
| Adjusted R-Squared | 0.68 | 0.68 | 0.68 |

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

Powers of the funding status variables include (Underfunding$_{i,t-1}$ / $A_{i,t-1}$), (Underfunding$_{i,t-1}$ / $A_{i,t-1}$)$^2$, (Underfunding$_{i,t-1}$ / $A_{i,t-1}$)$^3$, (Overfunding$_{i,t-1}$ / $A_{i,t-1}$), (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

# Two-Stage Specifications

Version 1. Instrument for Total Pension Contributions

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

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

Version 2. Instrument for Total Cash Flow

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

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

# IV Results

| | *2nd Stage Dependent Variable: $CAPX_{i,t}$ (Capital Expenditures)* | | | | |
|---|---|---|---|---|---|
| Contributions (Total)$_{i,t}$ / $A_{i,t-1}$ | -0.852 *** | -0.782 ** | -0.905 *** | | |
| | (0.231) | (0.375) | (0.290) | | |
| Non-Pension Cash Flow$_{i,t}$ / $A_{i,t-1}$ | 0.116 *** | 0.115 *** | 0.116 *** | | |
| | (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 *** | -0.008 | -0.003 |
| | (0.001) | (0.001) | (0.001) | (0.012) | (0.016) |
| | *1st Stage Dependent Variable: 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 *** | | |
| | (0.001) | (0.001) | (0.001) | | |
| Underfunding$_{i,t-1}$ / $A_{i,t-1}$ | | 0.067 *** | 0.182 *** | | -0.001 |
| | | (0.007) | (0.006) | | (0.100) |
| Overfunding$_{i,t-1}$ / $A_{i,t-1}$ | | -0.016 *** | -0.015 *** | | 0.137 *** |
| | | (0.002) | (0.002) | | (0.030) |
| $Q_{i,t-1}$ | -0.0003 *** | -0.0003 *** | -0.0003 *** | 0.045 *** | 0.045 *** |
| | (0.000) | (0.000) | (0.000) | (0.002) | (0.002) |
| Observations | 8030 | 8030 | 8030 | 8030 | 8030 |
| Number of Firms | 1522 | 1522 | 1522 | 1522 | 1522 |
| Within R-squared First Stage | 0.25 | 0.27 | 0.19 | 0.11 | 0.11 |
| Within R-squared Second Stage | 0.09 | 0.09 | 0.09 | 0.13 | 0.13 |

# Sample Divisions

| | | | | Explanatory Variables | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Cash Flow | | $Q_{i,t-1}$ | | Mandatory | |
| 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 | 0.0050 | 0.104 | 7.627 | 0.021 | 7.480 | -0.958 | -2.12 |
| Voluntary Contributions (High) | 1422 | 0.0050 | 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 |
| Sometimes | 2627 | 0.111 | 0.333 | 0.094 | 5.79 | 0.022 | 5.93 | -0.420 | -0.84 |
| Often | 2498 | 0.375 | 1.000 | 0.091 | 4.88 | 0.030 | 5.46 | -1.523 | -3.18 |

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

# Main Result

- Capital expenditures fall by $0.60 per $1.00 of mandatory contributions
  - Broad sample (1500+ firms, 1990-1998 panel)
  - Even allowing generalized correlations between investment opportunities and pension funding status
- Suggests investment-CF sensitivities (generally around 0.1) are a *downward* biased measure of the dependence of investment on internal financial resources

## Interpretation of Results

- Investment clearly dependent on internal resources for a broad sample of firms
- Note lack of correlation between investment and the funding status in overfunded region
- Two possible explanations
  1. Funding status really is exogenous to investment opportunities
  2. Investment is not sensitive to investment opportunities → agency or optimism

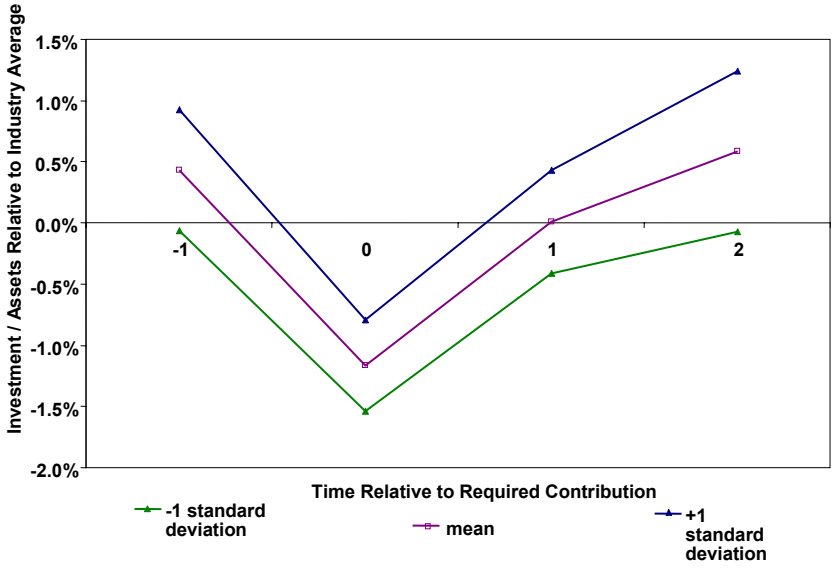
## Three Reasons Why Investment-CF Sensitivities Might Be Downward Biased

1. In a simple model, if output depends on investment and some unobserved productivity parameter, the *cross-partial* determines the direction of the bias
2. Cash flow as used in the literature may not really be *free* cash flow, implicitly pledged to other claimants (e.g. pension payments)
3. Could also argue that in some cases investment opportunities are negatively correlated with cash flows

# Aggregate Implications

- High required contributions depress investment for firms that sponsor DB plans
  - PBGC estimates aggregate mandatory contributions as $65.5bn in 2003
  - If 60% of that amount is cut out of investment, the investment drop amounts to 6.4% of 2002 capital expenditures
  - aggregate nonresidential fixed investment would be 3.6% lower
- Questions:
  - Is some investment shifted to future periods?
  - Do non-DB firms take up some investment opportunities that constrained DB firms leave on the table?

# Is Investment Shifted to Future Periods?




Sample of 94 firms with one large (>0.25% of assets) contribution year in which investment declined. Distribution of years: 18 in 1991, 9 in 1992, 12 in 1993, 15 in 1994, 12 in 1995, 12 in 1996, 9 in 1997, 7 in 1998.

# Problems