Valuing and Hedging Defined Benefit Pension Obligations – The Role of Stocks Revisited

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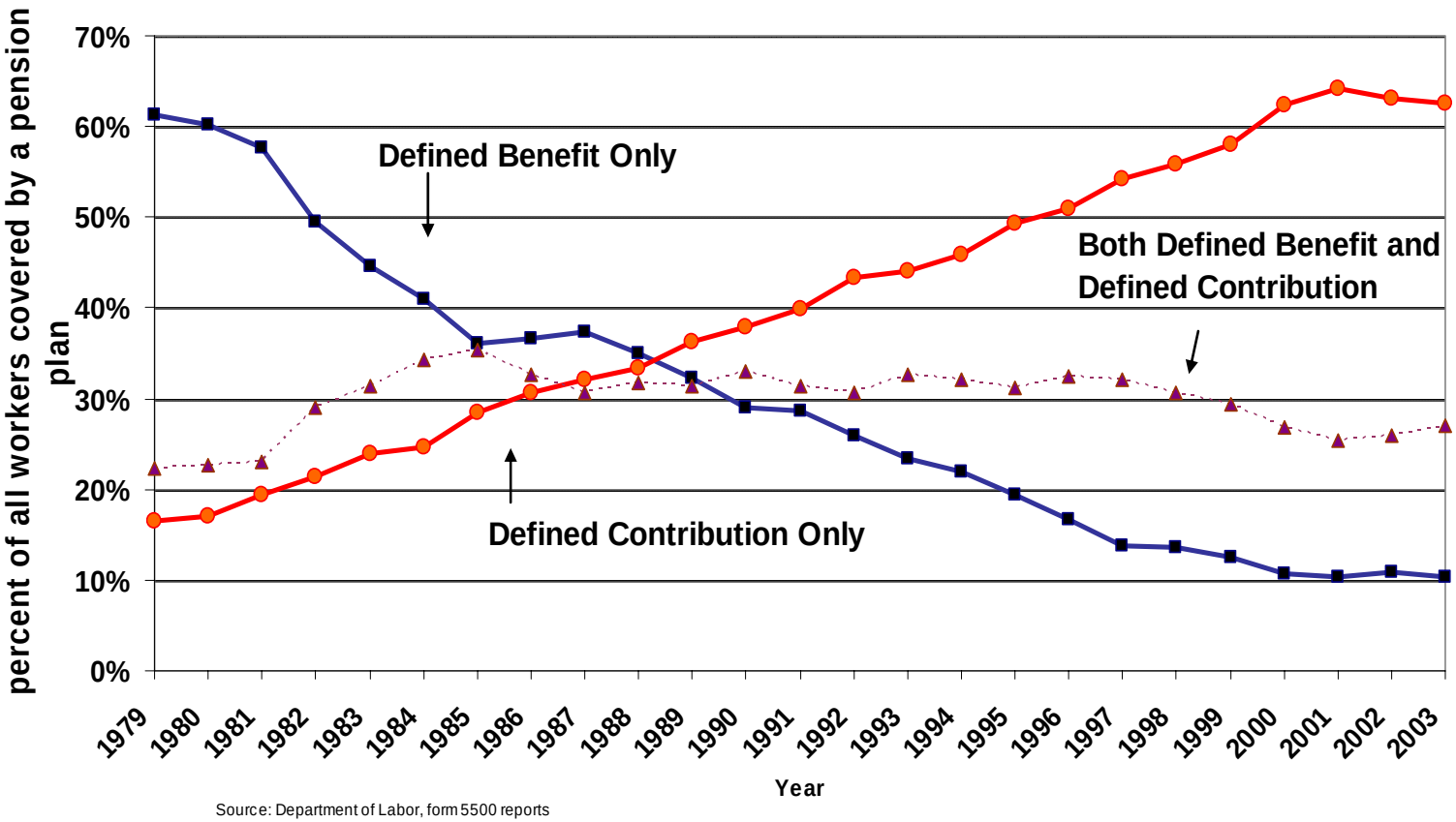
DB pension plans have attracted significant attention recently

- Bankrupt companies: transferred under-funded plans to gov't insurer (United Airlines, US Air, Bethlehem Steel)
- Healthy (and not-so-healthy) companies
  - closed DB plans to new workers (IBM, Alcoa, GM)
  - frozen DB plans for existing workers (IBM, Verizon, HP)
  - opened DC plans
- U.S. Congress recently passed pension reform bill to increase financial strength of gov't insurer (PBGC)
  - Increased funding, different accounting rules, …
- Financial Accounting Standards Board (FASB) and other regulatory bodies continue to discuss modifying rules for financial reporting of DB pensions
  - Discussion of moving from actuarial to market valuations

There has been a major decline in the relative prevalence of DB plans in the U.S.



Source: Department of Labor, form 5500 reports

But DB plans remain important

- Assets in private DB plans ≈ assets in DC plans
  - DC: $ 2.2 trillion DB: $ 2.0 trillion (2000)
    www.dol.gov/ebsa/PDF/2000pensionplanbulletin.PDF
- Still many participants in plans
  - Private sector workers (previous slide): ≈ 20 million
  - Retirees (excluded from previous slide): ≈ 24 million
  - Government employees (excluded from previous slide)

Big issues for DB pensions

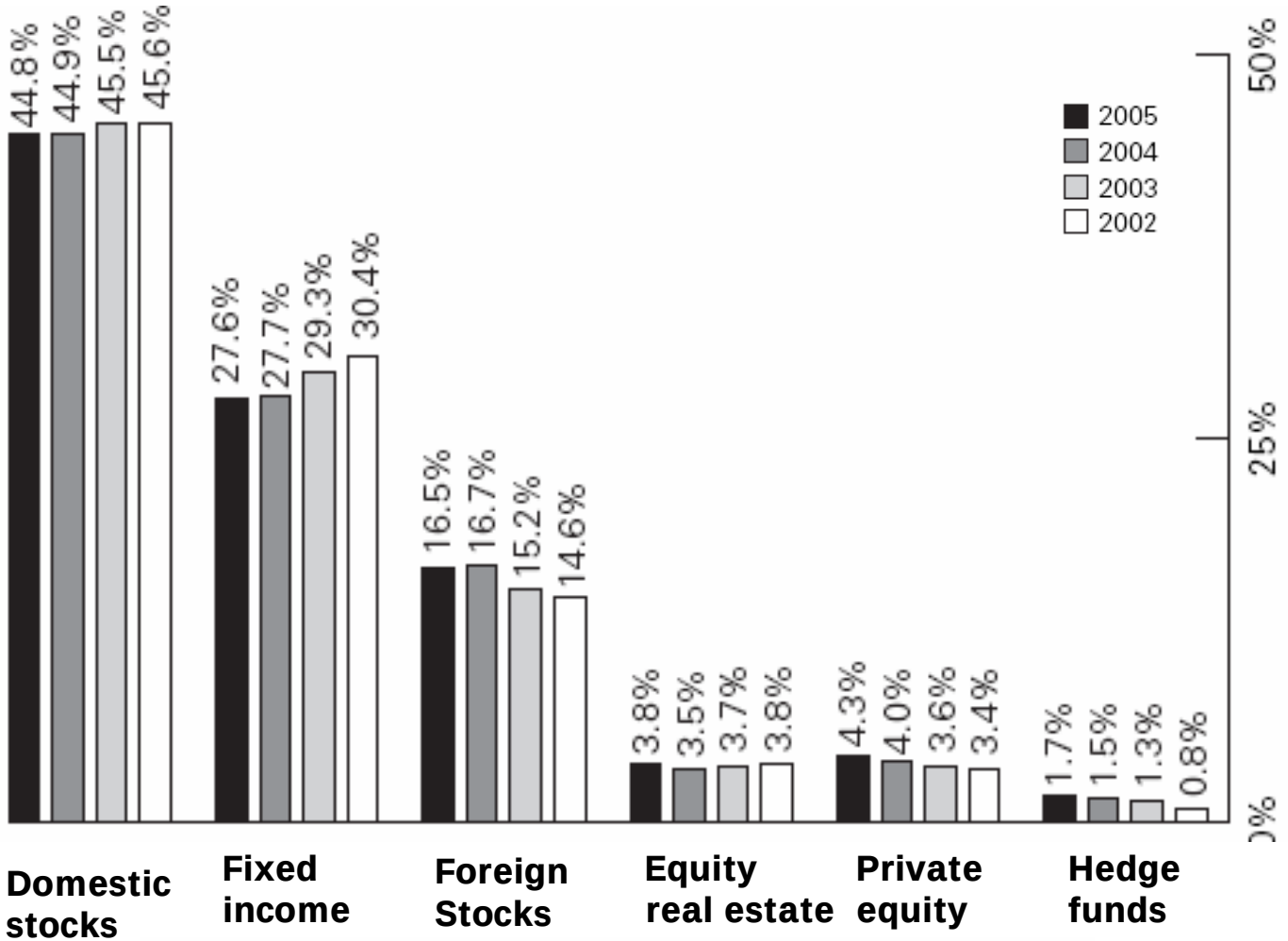
1. How to measure liabilities?
2. What are appropriate funding levels?
3. What is appropriate asset allocation?

- *Firms, workers, and regulators likely to answer these questions differently*

Debate over how much in equities a firm should hold in pension plan

- Popular practice: 60%
- Common finance academic advice: little or none
  - Bodie (1990, 2006)
  - Gold and Hudson (2003)
- Importance highlighted in 2000-2002
  - interest rates fell (raising PV liabilities)
  - stock market fell (lowering assets)
  - led to large drop in funding ratio
    - $38 billion under-funding in 2001, $139 billion under-funding in 2002

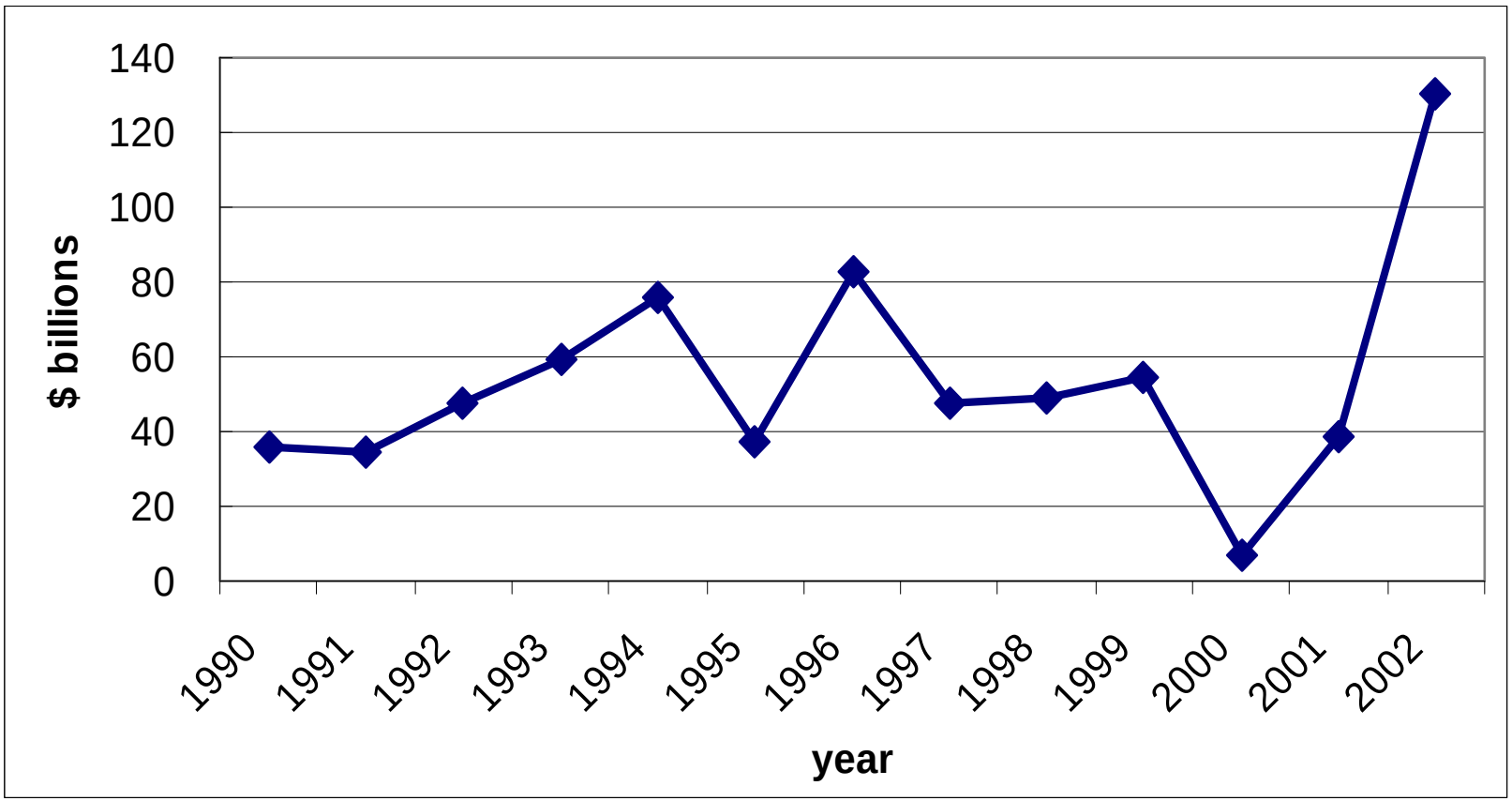
Asset Mix in U.S. Corporate DB plans



Note: Dollar-weighted and projected to a universe of 1,035 corporate funds in 2005, 1,008 in 2004, 1,005 in 2003, and 1,007 in 2002.

Source: Greenwich Associates

Under-funding in DB Plans



Single-Employer DB plans
Source: PBGC (2004)

Pension Asset Allocation: The Example of Boots (UK retailer)

- Shifted to 100% bond financing (2001), on recommendation by finance chief John Ralfe
- Partial shift back (2004) (15% equities and property) after Ralfe left
- Generated lots of debate within the UK and elsewhere

Our goal: re-examine key issues, incorporating long-run link between labor earnings and stock returns

- Measuring liabilities
  - Appropriate valuation model / discount rate
- Asset allocation
  - Does hedging demand justify holding stocks?

Previous literature on implications of wage/stock link for DB pensions

- Black (1989)
  - "Stocks go up when it looks like times will be good. In good times, wages … tend to grow faster than usual. Thus the broader your view of the pension liability, the more stocks you will need for hedging."
- Sundaresan and Zapatero (1997)
- Smith (1998)
- Cardinale (2004)

Outline for remainder of talk

- Defining liabilities
- A model for valuing and hedging liabilities
- Model results
  - Valuation and Hedging
    - Example of Alcoa
  - Estimating Discount Rates
    - Example of Alcoa
- Caveat on asset allocation
- Empirical evidence
- Conclusions and policy implications

Typical DB Benefit Formula

$$b_{iR} = k * N_{iT} * W_{iT}$$

- b_{iR}: annual benefits throughout retirement
- k: fixed percentage (e.g. 2%)
- T: year preceding separation, retirement, or plan freezing
- N_{iT}: number of years worked through T
- W_{iT}: earnings in year T

Measures of pension liabilities (narrow → broad)

i) $\Sigma_{\text{current workers}}\ b(k, N_{it}, W_{it})$	(ABO)
ii) $\Sigma_{\text{current workers}}\ b(k, N_{it}, W_{iT})$	(PBO)
iii) $\Sigma_{\text{current workers}}\ b(k, N_{iT}, W_{iT})$	(Broad PBO)
iv) $\Sigma_{\text{current+future workers}}\ b(k, N_{iT}, W_{iT})$	(All-inclusive PBO)

t: current year
T: year prior to separation (random as of t)

Measures of Pension Liabilities: Discussion

- ABO
  - Legal obligation of the firm based on accrued liability
  - Future payouts fixed in nominal terms
  - Uncertainty about length of payouts (longevity)
  - Very bond-like (+ longevity bond)
- PBO
  - Takes into account that future payouts depend on realizations of future labor earnings
  - Potential to be correlated with stocks
- Broad PBO
  - Also includes anticipated tenure effects
  - May be most relevant for firm's asset liability management
- All-inclusive PBO

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The Model – Overview

- We compute the current market value of the firm's future pension outflows
  - We consider the pension plan as a "stand-alone" obligation
  - Main focus is on "broad PBO," but same approach is applicable to many possible measures

- How our approach differs from existing literature:
  - Computes market value (vs. actuarial value)
  - Uses an options pricing approach
  - Incorporates new evidence on the long-run correlation between labor earnings growth and asset returns

The model – empirical observations we want to capture

- Low annual correlation between aggregate wage growth and stock returns (e.g., Goetzman, 2005)
- Labor earnings growth much smoother than stock returns
- Labor earnings and stock prices are positively related in the long run
  - Direct evidence: Cardinale (2004), Benzoni et al (2006)
  - Indirect evidence:
    - Dividend growth and consumption growth become more correlated over longer horizons (e.g., Bansal and Yaron (2004), Hansen, Heaton and Li (2005), Julliard and Parker (2005))
    - Labor earnings and consumption highly correlated over medium and long horizons
  - For a dissenting view, see Lustig and van Nieuwerburgh (2006)

The Model – Stock Returns

- Stocks follow a log-normal diffusion
- Only stock market risk is priced

$$S_{t+h} = S_t \exp\left((r_s - div - .5{\sigma_s}^2)h + \sigma_s\sqrt{h}(dz_s)\right)$$

The Model – Labor Earnings

- Human capital
  - Log-normal diffusion term (idiosyncratic risk)
  - Pulls at the rate γ to a target ratio of human capital to stock (T*)
  - Labor earnings are like a dividend payment

$$H_{t+h} = H_t \exp\left((\alpha - .5\sigma_w{}^2)h + \sigma_w\sqrt{h}(dz_w)\right) + \gamma h\left(T^* - \frac{H_t}{S_t}\right)S_t - W_t$$

- Labor earnings
  - Pull towards target payout on human capital (sticky)

$$W_{t+h} = W_t + \beta(r_w H_t h - W_t)h$$

Model Parameters: labor earnings and stock returns

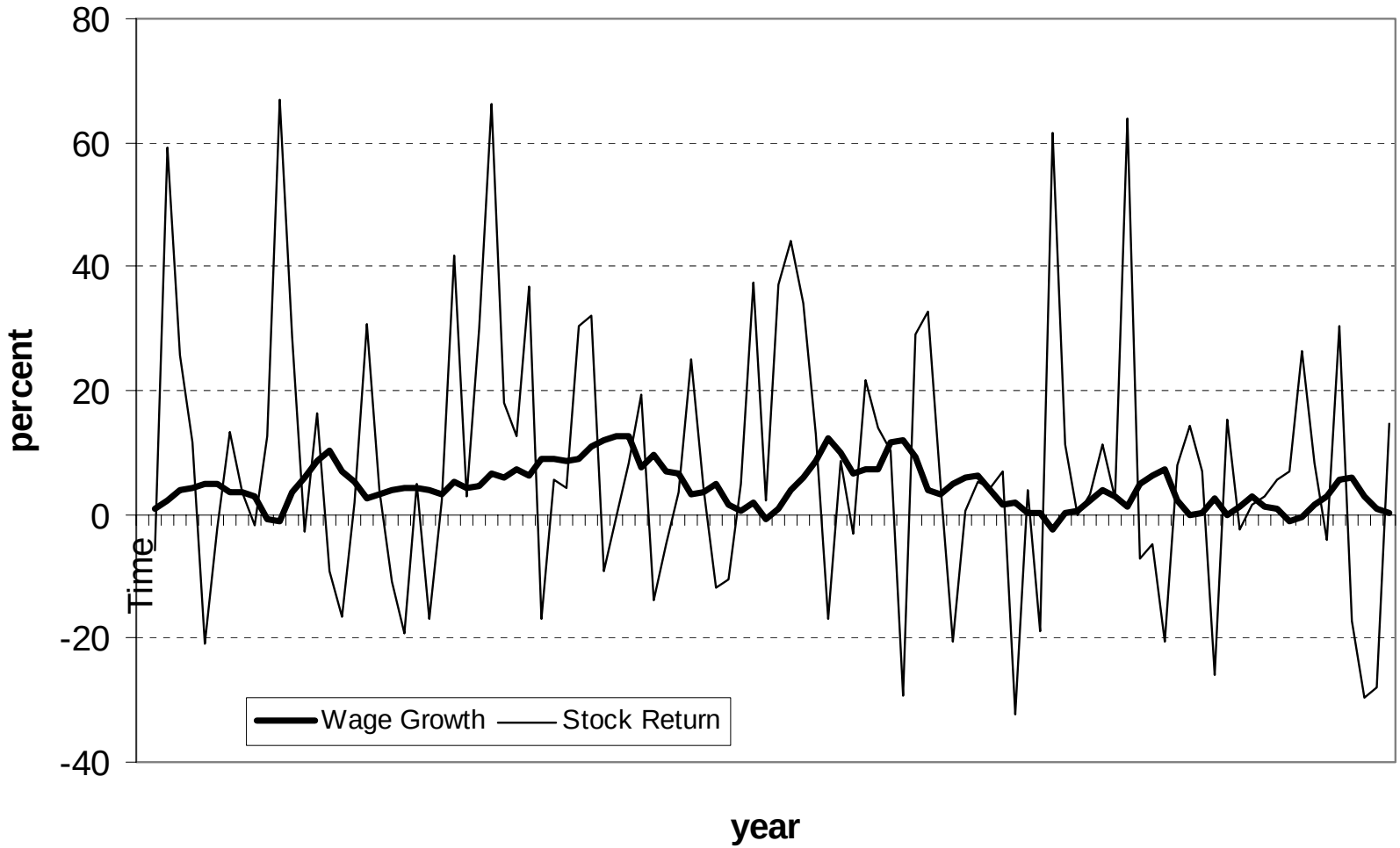
mean stock return (r_s)	0.05
payout rate on human capital (r_w)	0.02
dividend yield (div)	0.02
std dev stock return σ_s	0.18
std dev idio. human capital return (σ_w)	0.04
risk free rate (r_f)	0.02
mean growth human capital (α)	0.02
reversion of human capital to target (γ)	0.10
speed of reversion in labor earnings (β)	0.33

Implied model correlations between wage growth and stock returns

1-year correlation	-0.01
3-year correlation	0.11
5-year correlation	0.22

Based on non-overlapping 1, 3, and 5 year intervals, simulation results

Figure 1: Wage Growth and Stock Returns



Model Parameters: separation, life expectancy, bankruptcy

Table 1: Annual Separation Rates	
separation rate x < age 35	0.060
separation rate age 34 < x < age 46	0.045
separation rate age 45 < x < age 56	0.040
separation rate age 55 < x	0.050

Based on Poterba, Venti, Wise (2005)

- **The mortality rate: 0.3% per year for workers less than 65, and 5.0% per year for workers after 65 (SSA Trustees Report).**

- **The probability of bankruptcy is 0.5 percent per year, independent of the value of the stock market.**

Valuation: Methodology

- Key observation: Pension obligations can be valued as derivative securities
- Monte Carlo simulation (risk neutral probabilities)
- Each year, random draws determine the innovations to stocks and earnings, as well as whether worker separates or dies
- Calculate the future value of benefits at separation or retirement
- Future value discounted to present using risk neutral measure
- Present value is average across many simulations

Hedging: Methodology

- Valuation method also implies hedging strategy
  - Finding share of stock in hedge portfolio (δ)
    - Run parallel Monte Carlo simulation run using same shocks, different initial stock value
    - Estimate sensitivity of market value of liability to change in initial stock value (the δ)
  - Investing a fraction δ in the stock market equates sensitivity of hedge portfolio and sensitivity of liability to a change in stock price
  - Resulting stock investment share is time varying!

Computing Discount Rates: Methodology

- Traditionally, liabilities discounted at fixed discount rate
- Model shows that no single rate is theoretically correct
- But model can be used to approximate a single rate
- Define discount rate (IRR) as: rate such that model value of liabilities = discounted value of average future benefits (under true probability measure)

Caveats regarding the model

- Assumes that some risks are not priced
  - labor earnings risk that is orthogonal to the stock market
  - aggregate mortality risk
- Assumes away correlations between
  - job separations and stock market
  - firm-specific productivity shocks and firm-specific labor earnings
- Assumes aggregate shocks affect individuals proportionately at all ages; and flat age/earnings profile
- Ignores inflation risk
- Ignores interest rate term structure

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Valuation and Hedging: Qualitative Results

- Share of stocks in optimal hedge portfolio varies with
  - Status of participants (active vs. retired)
    - Mostly active → large stock share
    - Mostly separated or retired workers → small stock share
    - Separation triggers portfolio rebalancing, with stocks sold and replaced by bonds.
  - Age of active employees
    - Optimal hedge portfolio is dynamic, with the share of stocks decreasing in age.

Valuation and Hedging: The Case of Alcoa

- Data for 6,178 workers on salary, age, tenure
  (for "Plan 1" active workers in 2000)
- Alcoa's actual portfolio
  - 52% of pension assets in risky securities (domestic and foreign stock, and private equity)
- Model results
  - Share of stock in optimal hedge portfolio ranges from 86% for young workers to 8% for workers aged 62.
  - Weighted average share of stock for active workers is 57%
- But, this ignores non-active participants (separated and retired)

Table A1: Pension Benefits and Share of Stock in Hedge Portfolio (Alcoa Plan 1, Base Case Parameters)

# workers	Current age	Years worked	Current salary ($)	PV ($)	Stock %
108	27	0	38,289	64,202	86
41	27	7	44,062	99,829	78
178	37	7	64,252	181,088	76
262	37	12	69,805	247,057	74
90	47	7	64,493	206,624	66
303	47	22	76,549	436,409	63
214	57	32	85,997	699,528	33
61	57	37	82,801	764,553	32
34	62	32	71,451	599,670	8
24	62	37	89,897	860,155	8

Valuation and Hedging: The Case of Alcoa

- In 2003, Alcoa has 22,500 active participants, 34,500 retirees, 14,000 separated workers and 9,600 beneficiaries
- Model implies no stocks for non-active participants
- Taking into account the likely size of obligations to non-active participants (see text), the share of stock attributable to a hedging motive falls to 9.1 percent

Valuation and Hedging: Conclusions

- For firms like Alcoa with more retirees and separated workers than active participants, a hedging demand cannot justify the typical allocation of over 50% of pension assets to stocks
- For firms with a higher percentage of active participants, a significant allocation to stocks is perhaps justifiable
- Quantities are sensitive to parameters (e.g., speed of reversion to target human capital ratio), but these conclusions appear to be robust for a reasonable range of parameters

Discount Rates – The Case of Alcoa

- Implied discount rate found for each group of Plan 1 workers 
- Implied share of stock in discount rate decreases with age
- Weighted average for active workers implies stock share of **30.8%** in rate
- Taking into account retired and separated workers as above, share of stock in discount rate falls to **4.9%**

Table A2: Stock Share in Discount Rate and Hedge Portfolio: Alcoa Plan 1 Workers

# workers	Current age	Years worked	Share stock in discount rate	Share stock in hedge port.
108	27	0	0.53	0.86
41	27	7	0.47	0.78
…				
178	37	7	0.44	0.76
262	37	12	0.43	0.74
…				
90	47	7	0.36	0.66
303	47	22	0.33	0.63
…				
214	57	32	0.15	0.33
61	57	37	0.15	0.32
…				
34	62	32	0.04	0.08
24	62	37	0.04	0.08

Discount Rates – The Case of Alcoa

- Notice compression of discount rate share of stocks relative to hedge share of stocks for active workers
  - Explained by discount rates averaging periods of high and low stock holdings in hedge portfolio, due to separations
- Alcoa reports
  - Expected return on long-term assets of 9%
  - Discount rate of **7.75%** used to discount pension liabilities
- What does the model suggest?
  - Assume Treasury rate of 5.5%, expected stock return of 10%
  - 4.9% stock weight => discount liabilities at **5.7%**
  - Suggests liabilities are significantly understated in financial statements

Discount Rates: Conclusions

- Appropriate discount rate for liabilities = average rate of return on optimal hedge portfolio
- In practice, regulations require firms to use different discount rates for different calculations:
  - For earnings reporting, generally a few percentage points above Treasury rate, based on expected asset returns
  - For IRS/ERISA high quality bond yield
  - Further distortions from smoothing
- For companies like Alcoa with many retirees, discounting at high rates significantly understates pension liabilities in financial statements
- For firms with predominantly active workers, estimated pension liabilities may be close to, or even overstate, their true value

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From hedge portfolio to asset allocation

- Derived hedge portfolio for stand-alone liabilities
- Implications for pension fund asset allocation?
  - Should firm's hedge?
  - Which liability measure should/do they hedge?
    - Economic or accounting measures???
- One approach: write down explicit objective function and solve for optimal pension funding and asset allocation decisions (we'll pursue in future draft)
- For now, we use share of stocks in hedge portfolio as suggestive proxy for share from optimization problem

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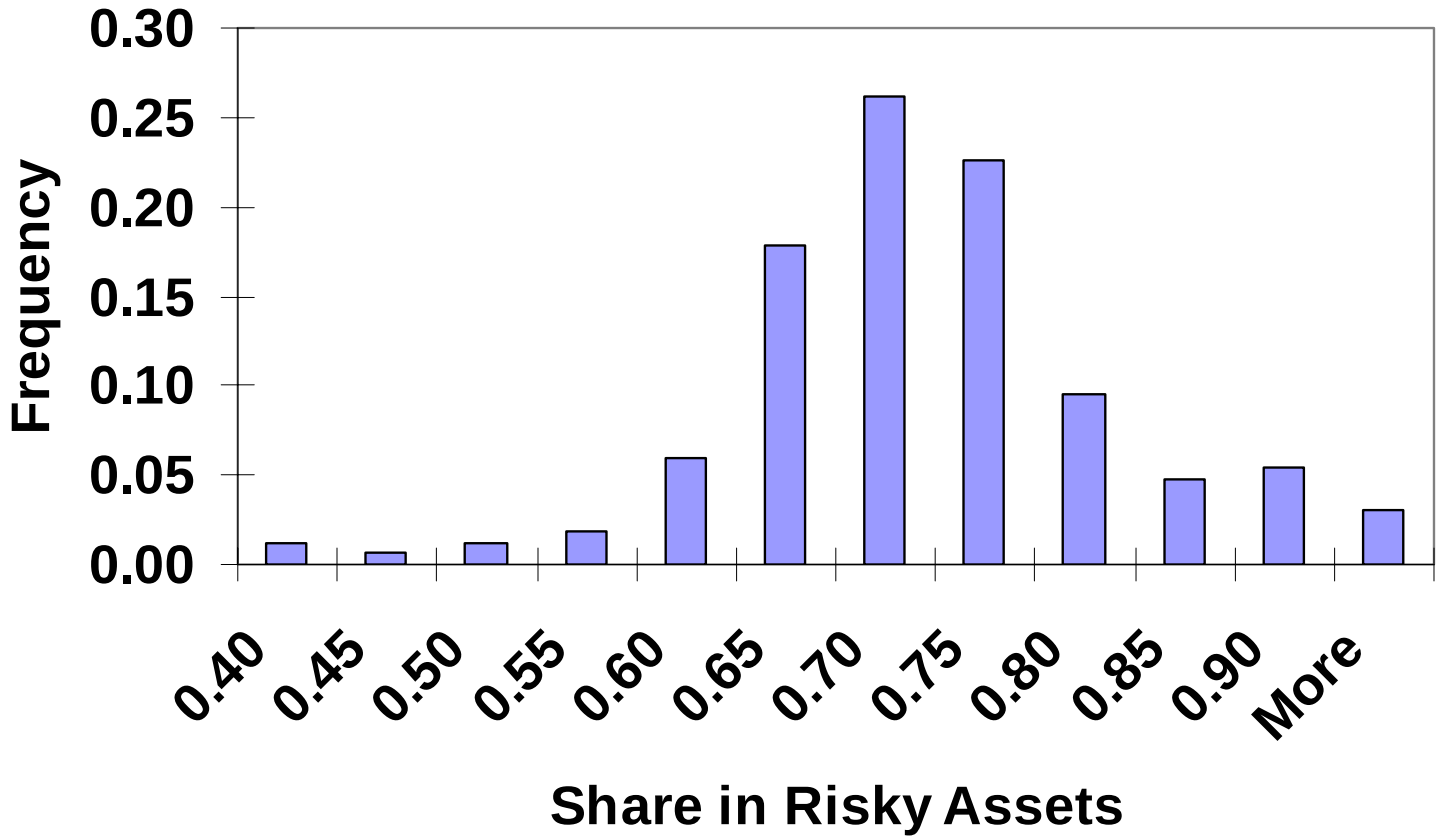
Empirical Evidence: Data Description

- Data on investment practices of 1,000 largest pension plans obtained from "Pensions and Investments," 2004 listing
- Matched with Compustat info on sponsor assets and liabilities, pension plan assets and liabilities, and info from Form 5500 on number of active, retired, separated and dependent participants
- Merton-type model used to estimate firm asset volatility and expected return on firm assets
- Matched sample has 168 firms, with pension benefit obligations totaling $900 billion (narrow PBO measure)

Figure 2
Distribution of Risky Asset Share



Source: Pensions and Investments, 2004, authors' calculations

Empirical Evidence

- Model suggests hypothesis:
  - Firms with a higher portion of active participants will invest a higher portion of pension assets in risky securities

- Several alternatives considered:
  - Moral hazard from PBGC insurance causes riskier and more under-funded firms to invest more in riskier asset classes (under-funding, asset volatility, leverage)
  - Higher expected return on firm assets makes managers reluctant to accept lower returns on pension assets, even if fair on risk-adjusted basis

Empirical Evidence

Risky Asset Share on Share Not Active

	COEF.	T-STAT	ADJ. R^2
share not active	-.119	-2.6	.032

- Small but significant negative relationship between equity share in pension assets and share of non-active participants
- Other regressions show relation between moral hazard indicators and stock share (consistent with Rauh)
- Firms with higher expected returns on operating assets held riskier pension portfolios

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Conclusions and Policy Implications

- Wage/stock link provides a potential rationale for holding stocks as DB pension assets
  - Firms with primarily retired or separated participants should hold bonds (they generally do not)
  - Firms with primarily young active participants should invest in equity
  - Overall, firms appear over-invested in equity relative to optimal hedge – still a question why is this?

Conclusions and Policy Implications

- Implications for financial reporting
  - Model could be used to construct rules-of-thumb for appropriate discount rates based on firm and participant characteristics.
  - Current FASB rule of crediting earnings with the average return on pension assets, while smoothing volatility of asset returns, provides an incentive to over-invest in risky securities.
  - Basing liability measurement on market values could encourage firms to hedge.

- Implications for gov't pension insurer (PBGC)
  - PBGC is like a very old firm (no active workers), and therefore a conservative investment policy is appropriate.
  - This may not, however, be a good model for young firms.

Conclusions and Policy Implications

- Would limits on risky pension investments be costly to sponsors, and hence plan participants?
  - Some academics have proposed severely limiting pension asset allocations to equities.
  - To the extent there is a hedging demand, such restrictions are likely to be most costly for young firms, who already are disinclined to provide DB plans.
  - Although risk needs to be controlled, overly restrictive regulation that discourages DB pension provision could also reduce welfare.

END