Reach for Yield by U.S. Public Pension Funds[#]

Lina Lu*, Matthew Pritsker*, Andrei Zlate**, Ken Anadu*

*Federal Reserve Bank of Boston

**Federal Reserve Board

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Roadmap

1. Introduction

2. Model of risky portfolio choice

3. Data:

   a) Measuring PPFs' portfolio risk

   b) Measuring underfunding

4. Empirical results:

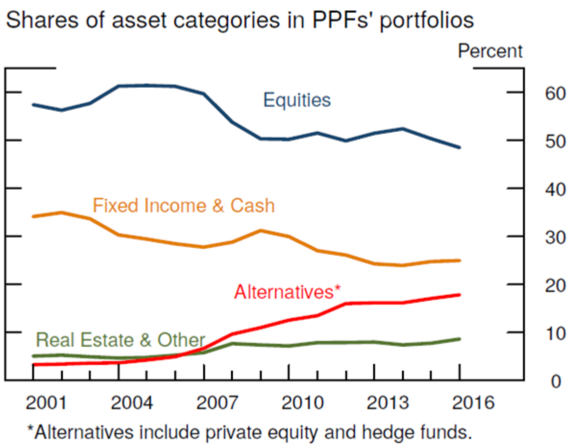
   a) Determinants of Asset Risk

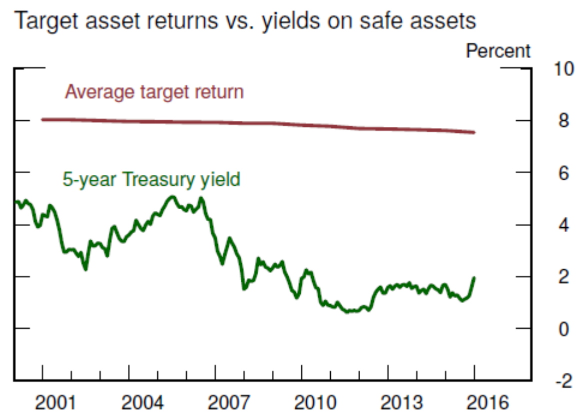
   b) Determinants of Net Worth Risk

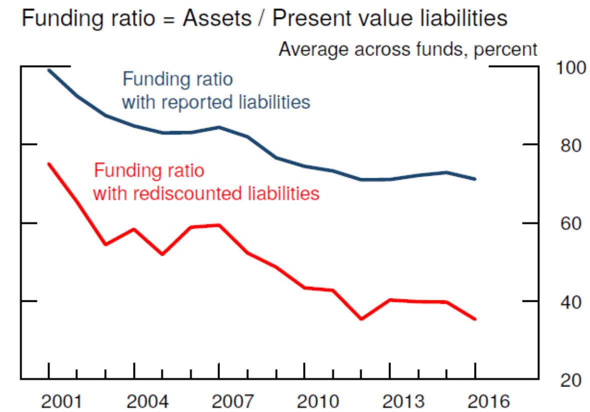
1. Introduction

- Document the risk-taking behavior of U.S. state & local public pension funds (PPFs).
- Contributions:
  - Theoretical model of risky portfolio choice.
  - Use Value at Risk to infer PPFs' risk with limited data.
  - Use high-frequency market indexes to estimate tracking indices for each asset class.
- Findings:
  - More underfunding, lower risk-free rates, weaker state finances → higher asset risk.
  - No evidence of higher net-worth risk for underfunded funds; only weak evidence for low interest rates.
- Interpretation:
  - Higher asset risk may not represent reach for yield, but pension funds' hedging of liabilities and net worth.

1. Introduction:







- Funds have increased portfolio allocations to higher yielding assets, i.e., alternatives, suggesting risk-taking.
- Low yields on safe assets vs. high target asset returns.
- Most PPFs are underfunded.
- Funding ratios are even lower with rediscounted liabilities (Rauh, 2017).

2. Model of risky portfolio choice

- PPF sponsor (state) acting on behalf of a representative citizen (RC).
  - Distinguish between RC vs. state debt holder.
- 2-period model (time 0 and t).
  - At time 0, the PPF invests in **risk-free** and **risky** assets, shares $(1-\omega)$ and ω.
  - At time t, it obtains $A_t = A_0[(1-\omega)e^{r_f t} + \omega e^{(r_f+\lambda-.5\,\sigma^2)t+\sigma t^{0.5}\varepsilon}]$.
  - Pension liability L_t is defined benefit, risk-free for beneficiaries.
  - Unfunded liabilities are covered with tax revenues, $T_t = \text{Max}(L_t - A_t, 0)$.
  - RC's consumption is $C_t = Y_t - D_t - T_t$, where Y_t is income, D_t is non-pension state debt, and T_t are taxes.
- Portfolio weight ω chosen to max $E\ U_t[\ Y_t - D_t - T_t\ ]$.

2. Model of risky portfolio choice

If the expression is > 0, the state must cover PPFs' unfunded liabilities

- Portfolio weight ω chosen to max $E_0\, U_t[\, Y_t - D_t - T_t\,]$:

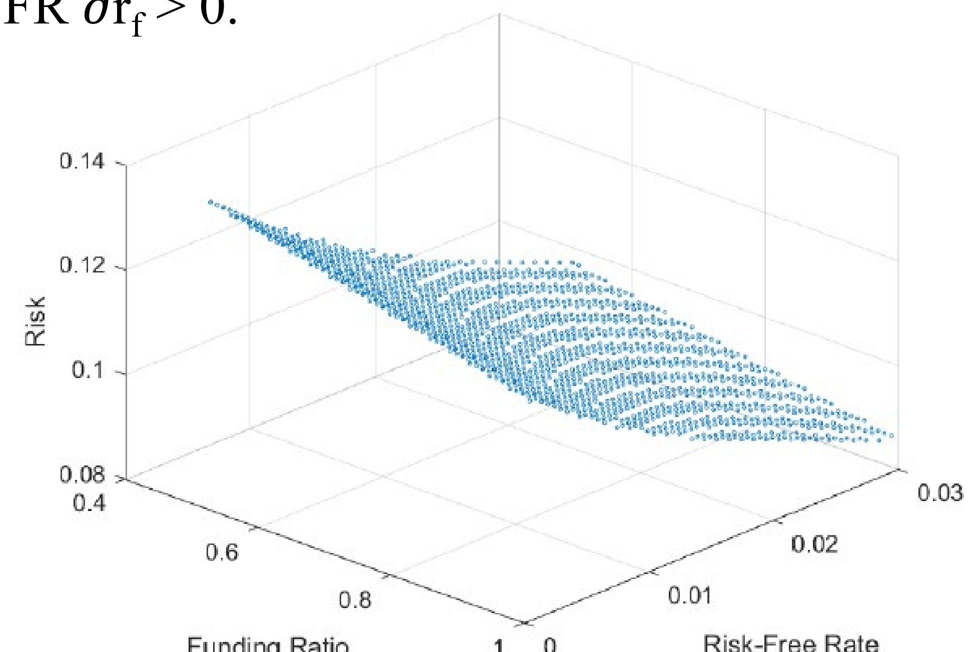
$$\max_{\omega}\ E_0\, U_t[Y_t \times \left(1 - SDI_t - PDI_t \times Max\left(1 - FR_0(r_f)\left[(1-\omega) + \omega e^{(\lambda - .5\sigma^2)t + \sigma\sqrt{t}\epsilon}\right], 0\right)\right)]$$

1. **Reach-for-yield channel**: $\partial\omega/\partial FR_0 < 0$.
   - If underfunded, a PPF could take more risk.
2. **Risk premium channel**: $\partial\lambda/\partial r_f < 0$ and $\partial\omega/\partial\lambda > 0 \rightarrow \partial\omega/\partial r_f < 0$.
   - If risk-free rate is lower, the risk premium is higher, PPFs could take more risk.
3. **Risk-shifting to state debt holders:**
   - State defaults on non-PPF debt if penalty γ is low, or if taxes/income, CRRA, or state debt/income are high:

$$\gamma \leq U_t'(Y_t - T_t) \times \left(1 + .5 \times CRRA \times \frac{SDI_t}{1 - \frac{T_t}{Y_t}}\right)$$

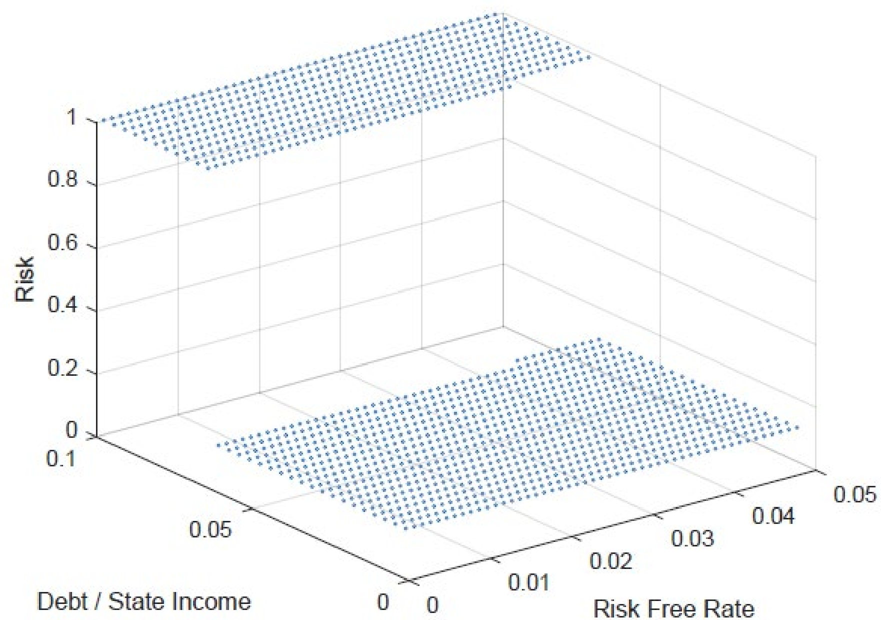
2. Model of risky portfolio choice

- With risk-free state debt (no default):
  - $\partial\text{Risk} / \partial\text{FR} < 0$.
  - $\partial\text{Risk} / \partial r_f < 0$.
  - $\partial^2\text{Risk} / \partial\text{FR}\, \partial r_f > 0$.



2. Model of risky portfolio choice

- With risky state debt (possibility of default):
  - Risk-taking jumps for high state debt/income ratios (SDI).
  - When SDI is high enough, risk-taking also jumps for low risk-free rates.



3a. Data: measuring PPFs' portfolio risk

- Limited data (Boston College Center for Retirement Research):
  - PPFs' annual asset returns
  - Portfolio weights in 6 asset categories on a fiscal year annual basis
  - Data from 2001 to 2016
  - Up to 170 PPFs.

- New approach to measure the riskiness of each PPFs' asset portfolio:
  - Identify the mix of market indexes relevant for each asset class.
  - Use these market indexes to estimate daily returns for each asset class.
  - The estimated returns for each asset class allow to construct better measures of risk, e.g., VaR.

3a. Data: measuring PPFs' portfolio risk

- We assume that each PPF $i's$ return for asset class *c* is driven by a *category index* common across funds plus a fund-specific *tracking error*:

$$r_{c,i,t} = r_{c,t} + \epsilon_{c,i,t} \qquad (1)$$

- For each asset class *c*, the category index return is a linear combination of *market index* returns:

$$r_{c,t} = \sum_j r_{j,t}\theta_{c,j} \qquad (2)$$

- We estimate category indexes as linear combinations of market indexes that best explain PPFs' total returns conditional on their portfolio weights, using the OLS post-LASSO estimator:

$$r_{i,t} = \sum_{c=1}^{6} w_{i,c,t}\,(r_{c,t} + \epsilon_{c,i,t}) = \sum_{c=1}^{6}\sum_{j=1}^{J} w_{i,c,t}\, r_{j,t}\theta_{c,j} + u_{i,t} \quad (3)$$

The data available are in red.
We estimate $\theta_{c,j}$.

- **Using annual data**, we estimate panel equation (3) in two steps.
  1. Use LASSO to select relevant variables.
  2. Estimate $\theta_{c,j}$ coefficients for relevant variables with OLS.

3a. Data: measuring PPFs' portfolio risk, computing Value at Risk

- **Using daily returns** on the market indices and the estimated $\theta_{c,j}$ parameters, construct daily returns for category indices from (2).

- Compute the annualized variance-covariance matrix of the category indices:

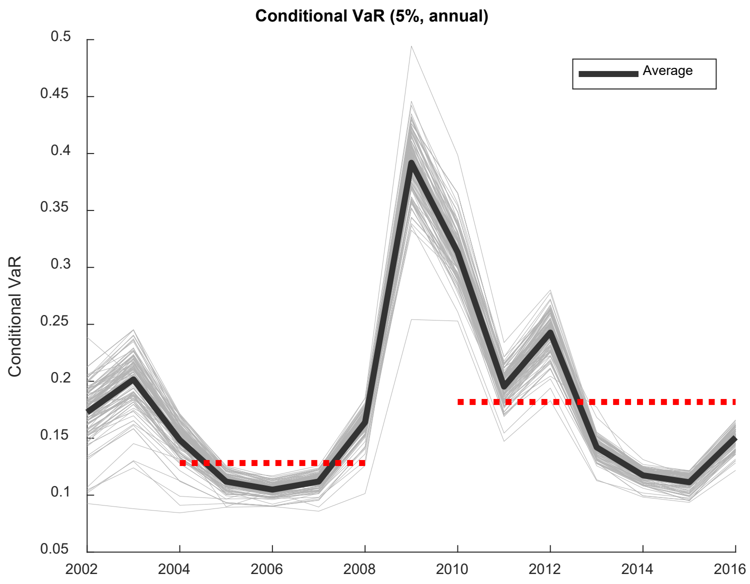
$$\Sigma_t = 250 \times \frac{1}{N} \sum_{k=1}^{N} R_{c,d_k,t-1} * R'_{c,d_k,t-1}$$

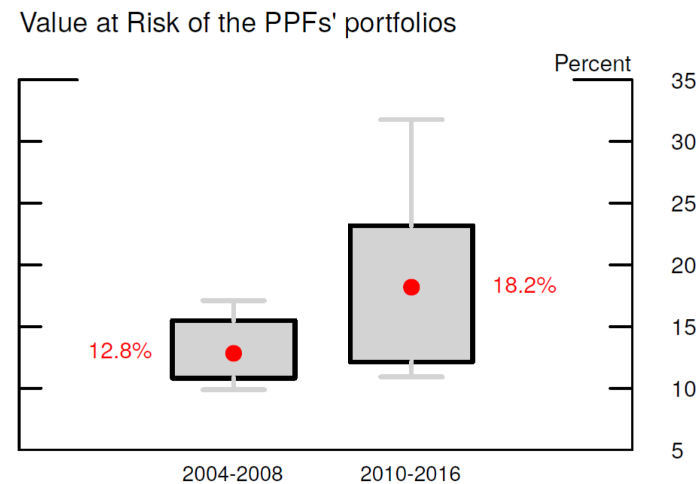
- Using the residuals from (3), we estimate σ_u^2 as the sample variance of funds' annual idiosyncratic risk.

- We compute VaR from the variance-covariance matrix of daily returns on category indices Σ_t, funds' residual risk σ_u^2 for each year, and funds' annual portfolio weights $w_{i,t}$:

$$VaR_{i,t}(5\%) = 1.65 \sqrt{w'_{i,t}\Sigma_t w_{i,t} + \sigma_u^2}$$

3a. Data: measuring PPFs' portfolio risk





Note: The red dots show the average portfolio risk across SLPFs for each interval. The lower and upper ends of the grey boxes show the 25th and 75th percentiles of risk; the whiskers show the 5th and 95th percentiles.

- VaR changes through time due to changes in economic conditions and changes in portfolio weights.

3b. Data: measuring underfunding, rediscounting liabilities

- Liabilities are under-valued because discount rates are based on expected asset returns:
  - *"Finance theory is unambiguous that the discount rate used to value future pension obligations should reflect the riskiness of the liabilities. In actual practice, state and local plans generally set their discount rates based on the characteristics of the assets held in the pension trust rather than the characteristics of the pension liabilities." Jeffrey Brown and David W. Wilcox (2009).*

- To re-value total pension liabilities (TPL), we use the approach in Rauh (2017):
  - Infer liability duration and convexity from new regulatory data (GASB 67) fro 2014-16.
  - Use duration-matched Treasury yields as appropriate discount rates (r') and a Taylor series approximation around the reported TPL:

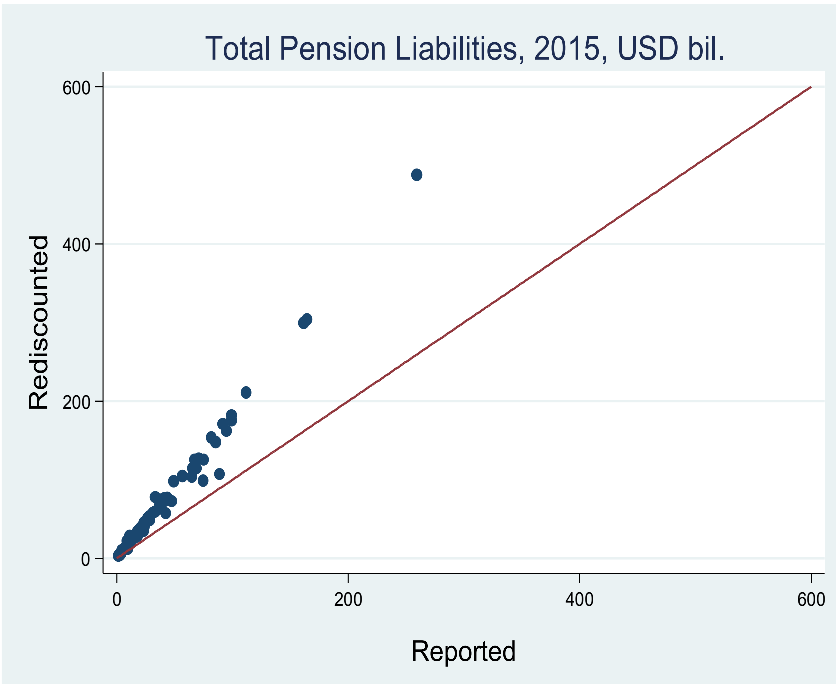
$$TPL_{r'} = TPL_r - TPL_r * Duration * (r' - r) + 0.5 * TPL_r * Convexity * (r' - r)^2$$

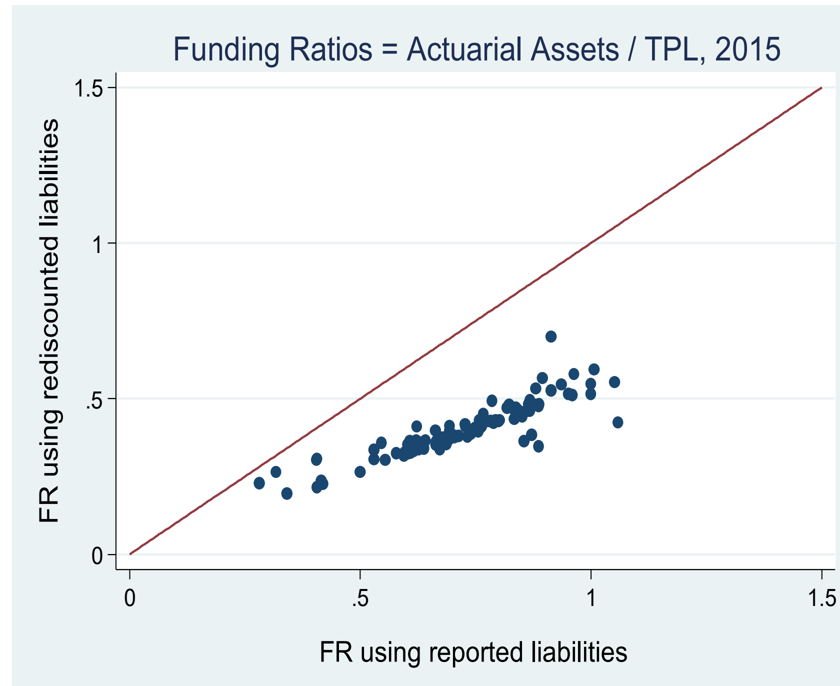
$$Duration = -\frac{\partial TPL/\partial r}{TPL_r} = -\frac{TPL_{\{r+0.01\}} - TPL_{\{r-0.01\}}}{0.02 * TPL_r}$$

$$Convexity = \frac{\partial^2 TPL/\partial^2 r}{TPL_r} = \frac{TPL_{\{r+0.01\}} + TPL_{\{r-0.01\}} - 2 * TPL_r}{(0.01)^2 * TPL_r}$$

3b. Data: measuring underfunding, rediscounting liabilities

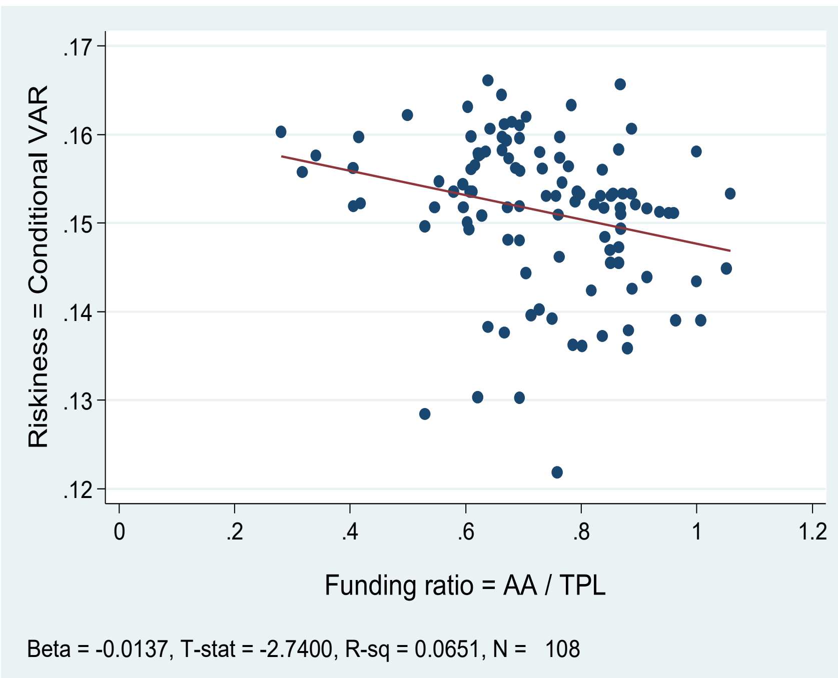
- Rediscounting results in higher liabilities and lower funding ratios.

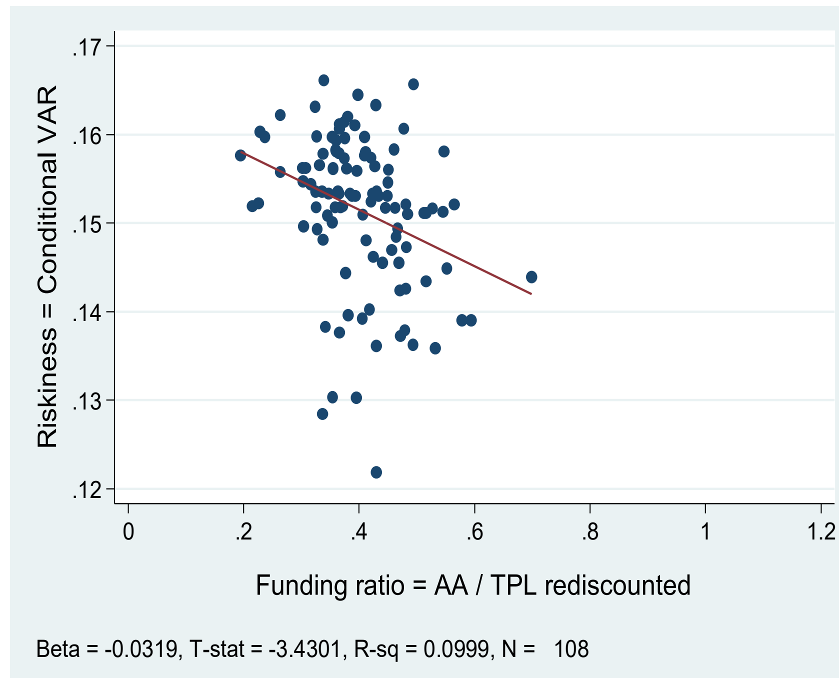




4a. Determinants of asset risk: underfunding, cross-section

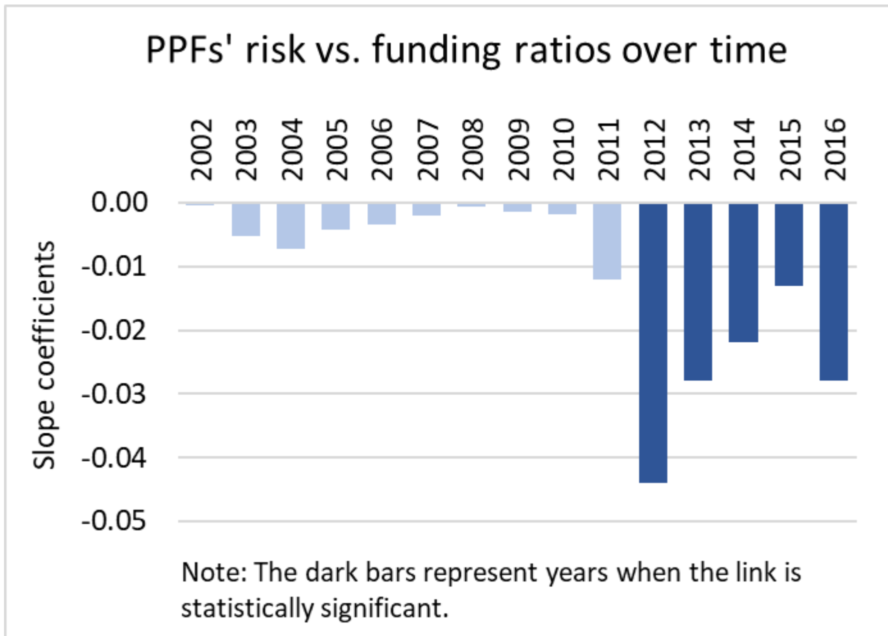
- Negative link between portfolio risk and lagged funding ratio in 2016.
  - Left chart: reported funding ratios are upward biased, measured with error.
  - Right chart: rediscounting increases the slope and statistical significance.





4a. Determinants of asset risk: underfunding, cross-section over time

- Rediscount actuarial liabilities, using duration and convexity available for 2014-16 only, adjusted for demographics.
- Measure $FR_{i,t}$ = actuarial assets/rediscounted actuarial liabilities.
- The negative link between risk and lagged funding ratios is strong in recent years, a period with low returns on safe assets.



4a. Determinants of asset risk: underfunding and rates, panel

- $VaR_{i,t} = \alpha + \beta * FR_{i,t-1} + \gamma * TrYield_t + \delta * FR_{i,t-1} * TrYield_t + \varepsilon_{i,t}$

VARIABLES	(1)	(2)	(3)	(4)
	VaR assets			
FR	-0.020***	-0.054***	-0.021***	-0.0052***
	(0.00031)	(0.0019)	(0.0012)	(0.00034)
TRY 5yr	-0.021**	-0.021**		
	(0.0075)	(0.0075)		
FR * TRY 5yr		0.013***		
		(0.0012)		
Dummy post-GFC			0.054*	0.053*
			(0.029)	(0.029)
FR * Dummy post-GFC				-0.034***
				(0.0011)
Constant	0.21***	0.21***	0.13***	0.13***
	(0.033)	(0.033)	(0.011)	(0.011)
FR	Varying	Varying	Varying	Varying
FR rediscounted	Yes	Yes	Yes	Yes
Fixed effects	No	No	No	No
Observations	1,289	1,289	1,289	1,289
Funds	111	111	111	111
R-squared	0.209	0.210	0.184	0.184

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

- More risk associated with lower FR ($\beta < 0$).
- More risk associated with lower yields ($\gamma < 0$), especially for funds with lower FR ($\delta > 0$).
- As yields declined, the more underfunded funds reached for yield to compensate.
- Results consistent with model implications.

4a. Determinants of asset risk: government finances, panel

- $VaR_{i,t} = \alpha + \beta * TrYield_t + \gamma * StateFin_{i,t-1} + \delta * TrYield_t * StateFin_{i,t-1} + \varepsilon_{i,t}$

VARIABLES	(1) VaR	(2) VaR	(3) VaR	(4) VaR
TRY 5yr	-0.021**	-0.021**	-0.021**	-0.021**
	(0.0076)	(0.0076)	(0.0075)	(0.0075)
State DTI	0.033***	0.039***		
	(0.0025)	(0.0022)		
TRY 5yr * State DTI		-0.0023**		
		(0.00080)		
State bond rating			0.00085***	0.0017***
			(0.000017)	(0.000048)
TRY 5yr * State rating				-0.00036***
				(0.000013)
Constant	0.21***	0.21***	0.21***	0.21***
	(0.033)	(0.034)	(0.033)	(0.033)
Fixed effects	No	No	No	No
Observations	1,656	1,656	1,654	1,654
Funds	138	138	138	138
R-squared	0.209	0.209	0.209	0.209

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

- More risk associated with worse state finances ($\gamma > 0$).
- More risk associated with lower yields ($\beta < 0$), especially for funds in states with worse public finances ($\delta < 0$).
- Result consistent with model implications.

4a. Determinants of asset risk: robustness

- Results are robust with alternative specifications:
  - VaR that abstracts from “passive changes” in asset weights due to valuation changes.
  - Rediscount liabilities with duration-matched, high-quality corporate bond yields.
  - 1-year and 10-year Treasury yields.

- Results are weaker with more coarse measures of risk (share of alternatives).

4b. Determinants of net worth risk

- Alternative interpretation: PPFs may increase the riskiness of assets to match liabilities.
- Change in net worth of plan *i*:

$$\Delta NW_{i,t} = A_{i,t}R_{a,i,t} - L_{i,t}R_{l,i,t}$$

- Riskiness of net worth:

$$VaR(NW)_{i,t} = 1.65\sqrt{A_{i,t}^2\sigma_{R_{a,i,t}}^2 + L_{i,t}^2\sigma_{R_{l,i,t}}^2 - 2A_{i,t}L_{i,t}\sigma_{R_{a,i,t}}\sigma_{R_{l,i,t}}\rho_{R_{a,i,t},R_{l,i,t}}}$$

- Scale VaR by assets as a measure of pension fund size:

$$VaR\left(\frac{NW}{A}\right)_{i,t} = 1.65\sqrt{\sigma_{R_{a,i,t}}^2 + \left(\frac{L_{i,t}}{A_{i,t}}\right)^2\sigma_{R_{l,i,t}}^2 - \left(\frac{L_{i,t}}{A_{i,t}}\right)\sigma_{R_{a,i,t}}\sigma_{R_{l,i,t}}\rho_{R_{a,i,t},R_{l,i,t}}}$$

  - **VaR(NW/A) in part becomes a mechanical function of the funding ratio A/L.**

4b. Determinants of net worth risk: Simulation

- To examine the link between VaR(NW/A) and A/L beyond the mechanical link, **simulate pension fund data in which net-worth risk is unrelated to funding ratios:**
    1. For each fund i = 1,…N, create a simulated fund by matching fund i's asset and liability returns data with those of a randomly chosen fund $j \neq i$ (no replacement).
    2. Repeat step 1 for 1,000 times to create 1,000 random simulated data sets.
- Each simulated fund i's net-worth risk taking (normalized by matched A or L) is unrelated to its randomly-matched A/L by construction.
    - Any relationship with funding ratios is either mechanical or coincidental.
- We first estimate the regression 1,000 times using normalized risk estimates and funding ratios from simulated data.
- Then compare real-data regression estimates with the distribution of estimates using simulated data.

4b. Determinants of net worth risk (normalized by assets): panel

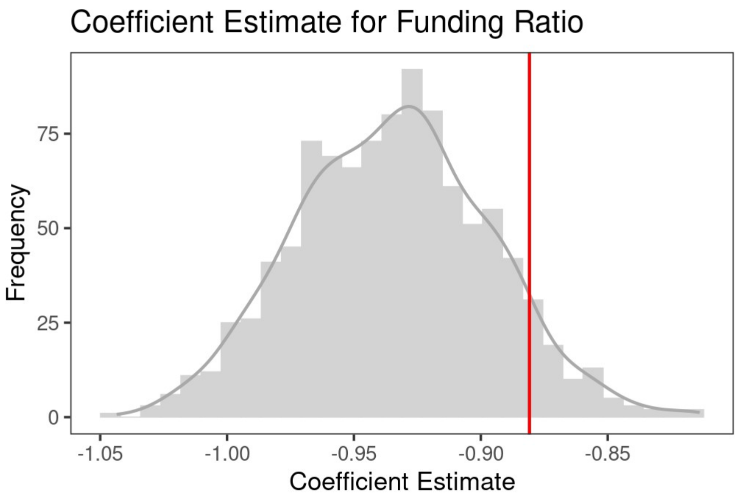
- $VaR_{i,t}\,(NW/A) = \alpha + \beta * FR_{i,t-1} + \gamma * TrYield_t + \delta * FR_{i,t-1} * TrYield_t + \varepsilon_{i,t}$

VARIABLES	(1) VaR	(2) VaR	(3) VaR	(4) VaR	(5) VaR	(6) VaR
FR	-0.881 ***	-1.483 ***	-0.955 ***	-1.758 ***	-0.893 ***	
	(0.927,0.073)	(0.574,0.426)	(0.970,0.030)	(0.947,0.053)	(0.928,0.072)	
TRY 5yr	-0.087 ***	-0.085 ***	-0.086 ***	-0.084 ***		-0.087 ***
	(0.075,0.925)	(0.049,0.951)	(0.080,0.920)	(0.027,0.973)		(0.075,0.925)
FR * TRY 5yr		0.215 ***		0.235 ***		
		(0.845,0.155)		(0.360,0.640)		
Constant	0.679 ***	0.674 ***			0.468 ***	0.689 ***
	(0.628,0.372)	(0.433,0.567)			(0.072,0.928)	(0.390,0.610)
FR	Varying	Varying	Varying	Varying	Varying	N/A
FR rediscounted	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects	No	No	Yes	Yes	No	No
Observations	1092	1092	1092	1092	1092	1092
Funds	91	91	91	91	91	91
R-squared	0.563	0.583	0.606	0.627	0.188	0.381

Robust standard errors in parentheses
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

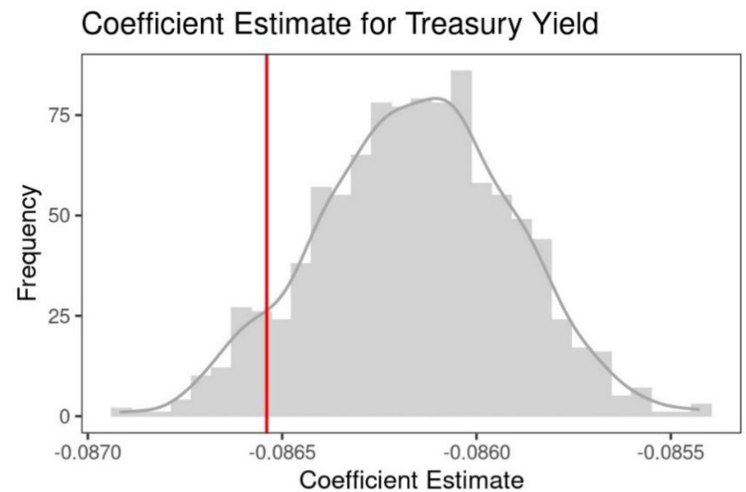
- Compare the regression estimate from real data to the distribution of simulation estimates.
- Is the link between VaR(NW/A) and FR weaker (or stronger) than implied by any mechanical relation?

4b. Determinants of net worth risk (normalized by assets): panel



p_val_left = 0.928
p_val_right = 0.072

- **No evidence of more net worth risk for more underfunded funds:**
  - Real-data relation between net-worth risk and funding ratios is not any more negative than implied by the mechanical relation.



p_val_left = 0.075
p_val_right = 0.925

- **Mixed evidence of more net worth risk in response to lower Treasury yields:**
  - Real-data coefficient on Treasury yields is lower than the simulation estimates, suggesting the relationship is not mechanical.
  - Result not robust with NW/L.

Conclusions

- We document the risk-taking behavior of U.S. PPFs.
- We use an innovative econometric approach:
  - Value at Risk for inferring PPFs' risk with limited data.
  - High-frequency market indexes to estimate representative tracking indices for each asset class.
- We find that more underfunding, lower risk-free rates, and weaker government finances are associated with more risk in asset portfolios.
- However, we find no evidence of higher net-worth risk for funds with lower funding ratios, and only weak evidence for low interest rates.
- Therefore, higher asset risk-taking may not represent reaching for yield, but instead may be consistent with some pension funds hedging their liabilities and net worth.
- Thank you!