Reach for Yield by U.S. Public Pension Funds

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1. Motivation

"[I]mportant classes of generally unlevered investors (for example, pension funds) are reportedly finding it difficult in the present low interest rate environment to meet nominal return targets and may be reaching for yield by assuming greater interest-rate and credit risk in their portfolios." Janet Yellen, June 2, 2011

1. Introduction

- This paper studies the risk-taking behavior of U.S. state and local public pension funds (PPFs). Findings:
  - Risk-taking is *on-average* related to low interest rates, underfunding, and sponsors' fiscal condition.
  - If transferred to sponsor states, the losses generated by a severe stress event—corresponding to PPFs 5% VaR—would have boosted state debt by about 40% in 2016.
- Contributions:
  1. Theoretical model to interpret risk-taking channels.
  2. New econometric approach for inferring funds' risk.
  3. Improved measures of underfunding based on recent data.
  4. Quantify fiscal consequences of risk-taking behavior.

1. Background: U.S. State and Local Public Pension Funds

- PPFs = important class of institutional investors, almost $4 trillion in assets.
- Most PPFs are underfunded (Funding Ratio = $\frac{PV\ (Assets)}{PV(Liabilities)}$ < 1)
- Liabilities are low risk:
  - Earned benefits are considered nearly risk-free because state constitutions and court precedents give public pension beneficiaries' claims very high seniority.
- U.S. public accounting (GASB) rules undervalue PPF liabilities because discount rates are based on funds' expected asset returns.

2. Two-date model of pension fund portfolio choice

- PPF sponsor (state) acting on behalf of a representative citizen (RC)
- 2 Dates, 0 and t.
- Date 0:
  - Pension fund assets A_0 invested in risk-free and risky assets.
- Date t:
  - Assets $A_t = A_0[(1-\omega)\, e^{r_f t} + \omega e^{(r_f+\lambda-.5\,\sigma^2)t+\sigma w(t)}\,]$
  - RC income Y_t, pension liability L_t, public debt payment D_t.
  - Pension taxes: $T_t = \mathrm{Max}(\mathrm{L_t} - \mathrm{A_t}, 0)$, Consumption: $C_t = Y_t - D_t - T_t$.
- Date 0 optimization:

$$Max_\omega \quad E_0\, U_t[C_t]$$

Two-Date Model Contd.

$$= \max_{\omega} E_0\, U_t[Y_t \times \left(1 - \frac{D_t}{Y_t} - \frac{L_t}{Y_t}\; Max\left(1 - \frac{A_0}{\frac{L_t}{e^{r_f t}}}\left[(1-\omega) + \omega\, e^{(\lambda - .5\sigma^2)t + \sigma\sqrt{t}\epsilon}\right], 0\right)\right)]$$

$$= \max_{\omega} E_0\, U_t[Y_t \times (1 - SDI_t - PDI_t \times \max(1 - FR_0(r_f, A_0, L_t)[(1-\omega) + \ \omega\, e^{(\lambda - .5\sigma^2)t + \sigma\sqrt{t}\epsilon}], 0))]$$

Risk-taking (ω) depends on:

- The Funding Ratio $FR_0\left(r_f, A_0, L_t\right)$ --- the reach for yield channel.
- The risk premium $\lambda\left(r_f\right)$ ------------- the risk premium channel.
- State debt to income SDI_t ---- the state finances channel and whether the state can default.

3. Measuring PPFs’ risk-1

- **Data is Limited:**
  - PPF’s annual asset returns and portfolio weights in 6 asset categories from 2001 to 2016 for 170 PPFs.

- **Other papers measure funds’ risk in a restrictive fashion.**
  - *Example 1:* Share of risky assets in portfolio, or portfolio asset beta.
  - *Example 2*: Value at Risk (VaR) assuming funds’ category returns are driven by a particular index.

3. Measuring PPFs' risk: **Our Paper**

- Each PPF $i's$ category return = a category index plus a fund-specific tracking error.

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

- Each category index is a linear combination of returns of traded indices.

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

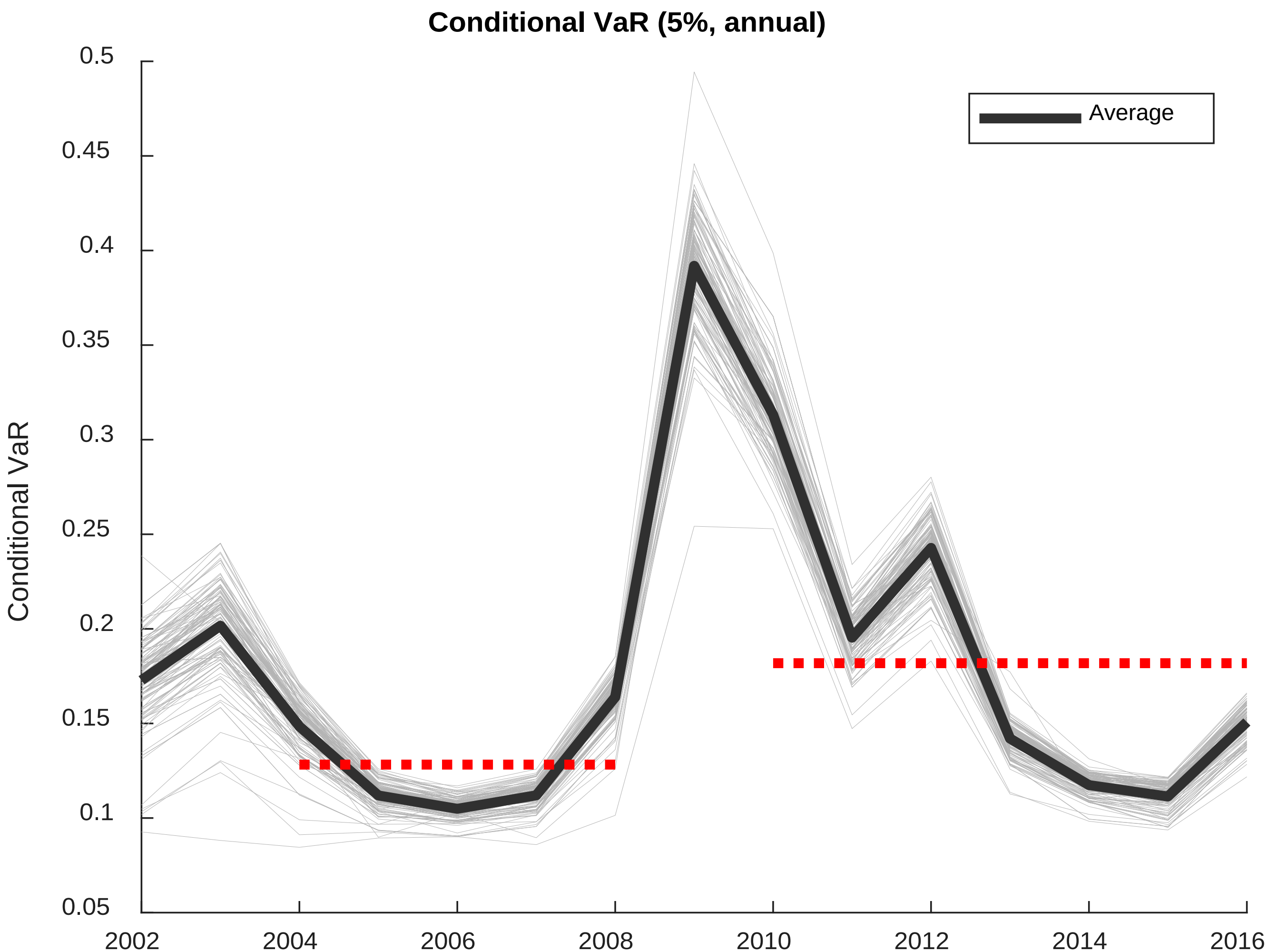
- We estimate the category indices ($\theta's$) that best explain funds returns given their portfolio weights.

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

- Equation (3) is estimated with the OLS post-lasso estimator.

- VaR estimated from var-cov matrices of category return indices, $\Sigma_{c,t}$ using annual daily data, funds' residual risks, σ_u^2, and funds' portfolio weights.

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



Conditional VaR (5%, annual)
Conditional VaR
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
2002
2004
2006
2008
2010
2012
2014
2016
Average

4. Measuring PPFs' underfunding: revaluing liabilities

- Liabilities are under-valued because discount rates are based on assets expected returns:

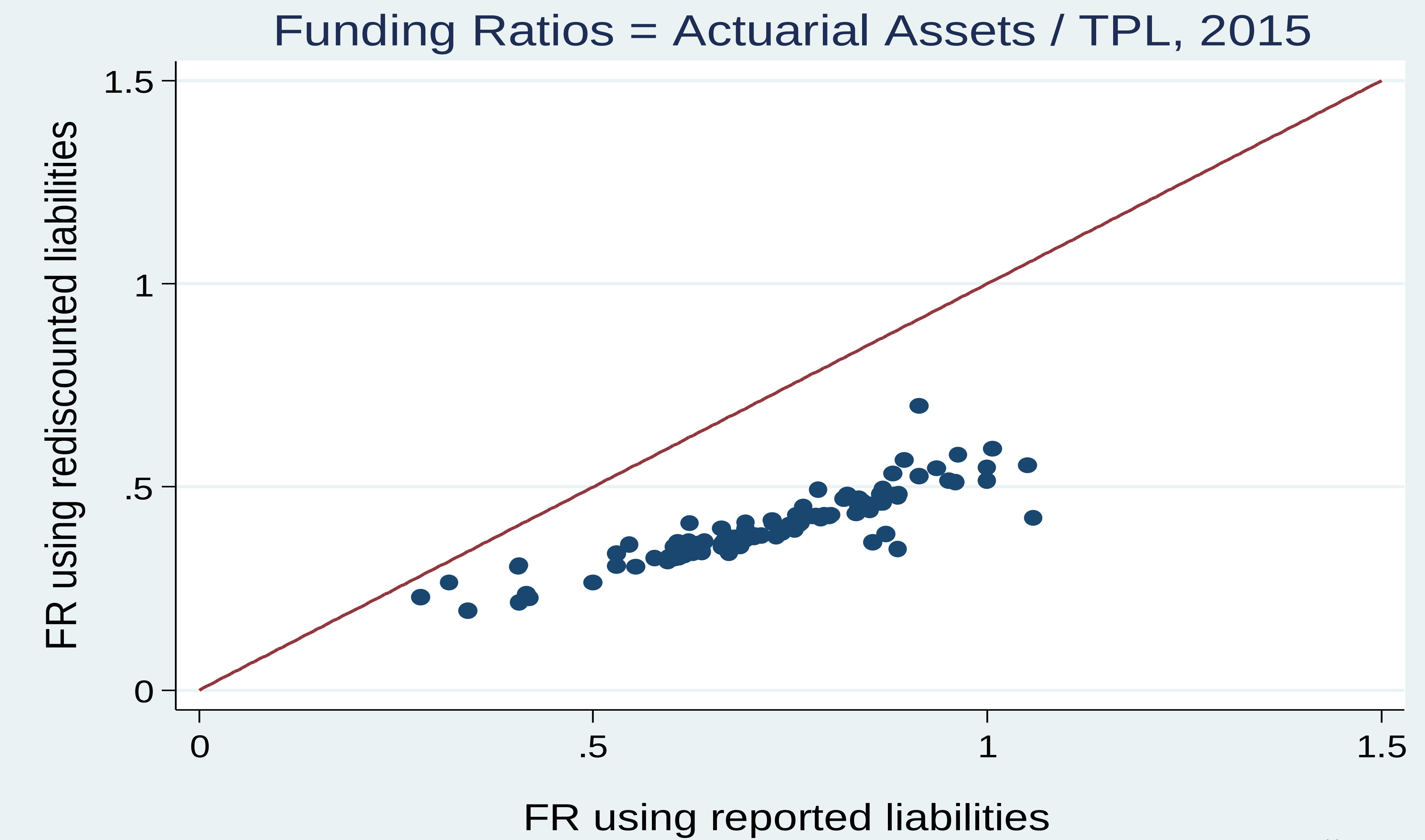
"Finance theory is unambiguous that the discount rate used to value future pension obligations should reflect the riskiness of the liabilities. In actual practice, state and local plans generally set their discount rates based on the characteristics of the assets held in the pension trust rather than 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):

1. We infer liability duration and convexity from new regulatory data (GASB 67).

2. We re-value the liabilities by Taylor-approximating their value if the discount rate changed from its reported value r to the appropriate (duration matched) risk-free rate r':

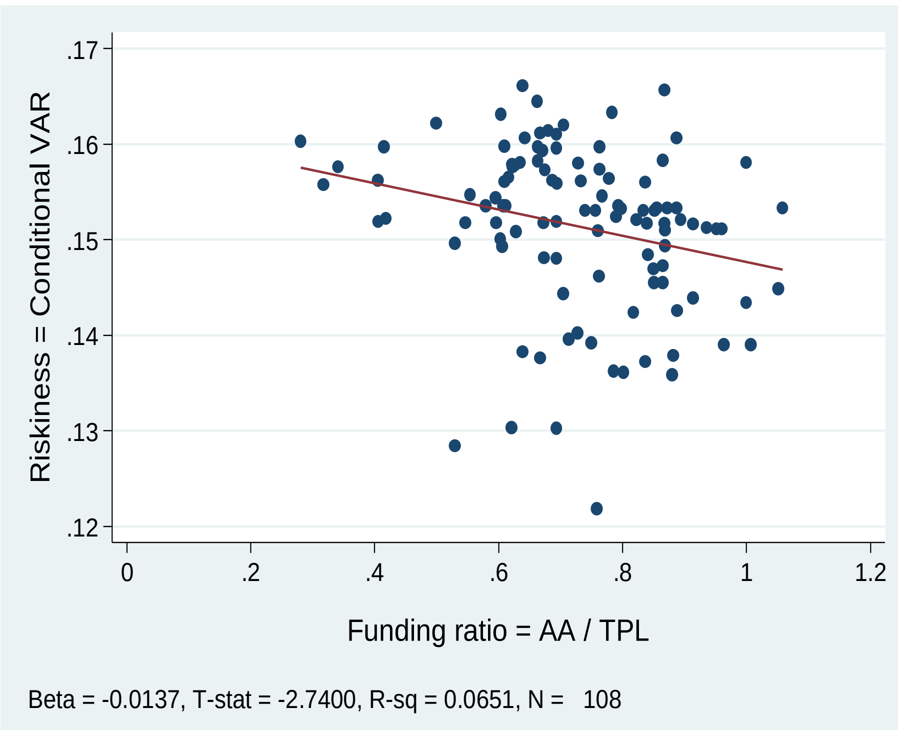
$$TPL_{r'} = TPL_r - TPL_r * Dur * (r' - r) + 0.5 * TPL_r * Convexity * (r' - r)^2$$

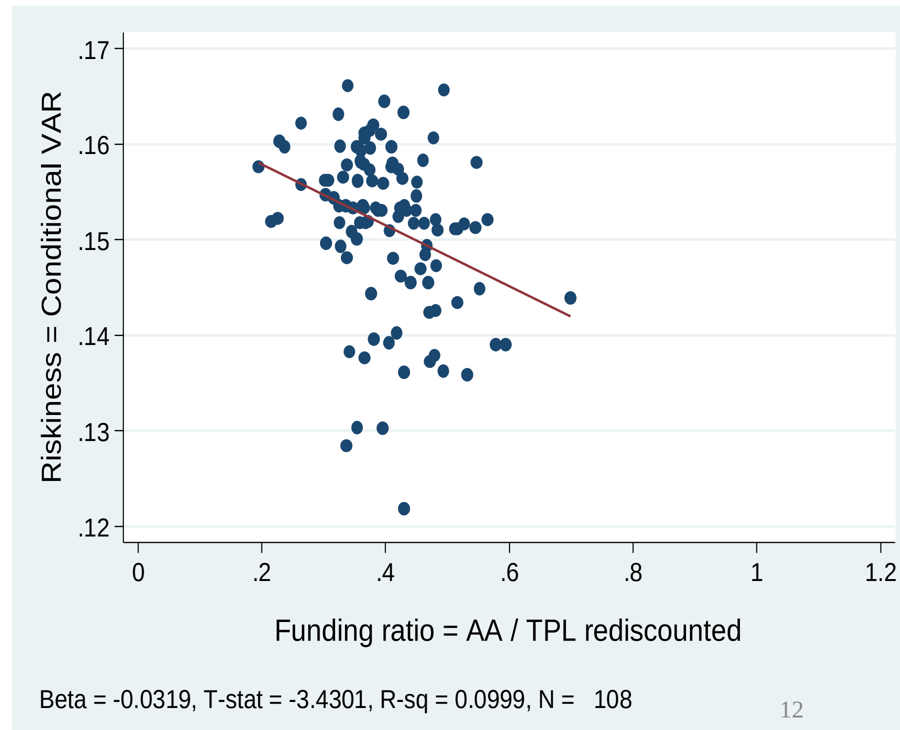


Funding Ratios = Actuarial Assets / TPL, 2015
FR using rediscounted liabilities
1.5
1
.5
0
0
.5
1
1.5
FR using reported liabilities

5. Findings: risk vs. underfunding, cross-section

- Risk (conditional VaR) vs. lagged funding ratio, 2016.
  - Left chart: reported funding ratios are upward biased, measured with error.
  - Right chart: rediscounting increases the slope and statistical significance.





5. Findings: risk vs. underfunding, panel

- Duration and convexity are only available for the most recent years.
- We use two approaches to rediscount liabilities over the full sample period (2001-2016):

1. Use the 2015 value of FR_p = as a proxy for past funding ratios.

2. Use the 2014-16 duration and convexity—adjusted for demographics—to rediscount past actuarial liabilities, $FR_{p,t}$

- While imperfect, both approaches provide a way to use all the panel data.
- They produce similar results.

5. Results. Regression of VaR on Fixed Rediscounted Funding Ratio by Year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Year:	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Dependent variable:	Conditional VaR														
FR rediscounted	-0.013	-0.0098	-0.012	-0.010	-0.010*	-0.013*	-0.024**	-0.080***	-0.057**	-0.038***	-0.054***	-0.025***	-0.018***	-0.016**	-0.032***
	(0.023)	(0.025)	(0.016)	(0.0081)	(0.0057)	(0.0069)	(0.011)	(0.028)	(0.023)	(0.014)	(0.018)	(0.0093)	(0.0062)	(0.0071)	(0.0093)
Observations	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108
R-squared	0.003	0.001	0.006	0.015	0.029	0.030	0.039	0.071	0.054	0.065	0.079	0.062	0.071	0.047	0.100

*p < 0.1, **p<0.05, ***p < 0.01.

- Underfunding is associated with more risk esp. when rates are low.
- Use of fixed funding ratio raises regression coefficients and R^2.
- Results are a bit weaker with variable funding ratios.

5. Panel Regression Result Overview.

- $Risk_{pt} = \alpha + \beta * FR_p + \gamma * TrYield_t + \delta * FR_p * TrYield_t + \varepsilon_{pt}$

  - Risk increases in underfunding (**reach-for-yield**). ($\beta > 0$)
  - Risk increases when treasury yields are lower. (**risk-premium channel**). ($\gamma < 0$)
  - Risk increases when more underfunding coincides with lower treasury yields. ($\delta > 0$)

- $Risk_{pt} = \alpha + \beta * State_{pt} + \gamma * TrYield_t + \delta * State_{pt} * TrYield_t + \varepsilon_{pt}$
- $Risk_{pt} = \alpha + \beta * State_{pt} + \gamma' * FR_p + \delta' * State_{pt} * FR_p + \varepsilon_{pt}$

  - Risk increases in state debt to income. (**risk-shifting**) ($\beta > 0$)
  - Risk increases in state debt to income when treasury yields are lower. (**risk-shifting**) ($\gamma < 0$)
  - When state indebtedness increases, the increase in risk is lower if funding ratios are lower (**no risk-shifting**).

5. Findings: risk vs. underfunding & rates, panel

- $Risk_{pt} = \alpha + \beta * FR_p + \gamma * TrYield_t + \delta * FR_p * TrYield_t + \varepsilon_{pt}$

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Conditional VaR	Conditional VaR	Conditional VaR	Conditional VaR	Conditional VaR	Conditional VaR
FR	-0.0089***	-0.035***	-0.013***	-0.052***	-0.0064***	-0.014***
	(0.00026)	(0.0026)	(0.0014)	(0.0050)	(0.00035)	(0.00096)
1 yr Tr Yield	-0.018**	-0.018**				
	(0.0069)	(0.0069)				
1 yr Tr Yield * FR	0.00077	0.0057***				
	(0.00052)	(0.0013)				
10 yr Tr Yield			-0.015	-0.015		
			(0.011)	(0.011)		
10 yr Tr Yield * FR			0.0016***	0.0077***		
			(0.00034)	(0.0011)		
Post-crisis					0.054*	0.054*
					(0.030)	(0.030)
Post-crisis * FR					-0.0021***	-0.020***
					(0.00024)	(0.0027)
FR rediscounted	No	Yes	No	Yes	No	Yes

- More risk associated with underfunding ($\beta < 0$), especially during periods of low risk-free rates ($\delta > 0$).
- The estimate of δ is larger, gains significance with rediscounted liabilities (columns 2, 4 and 6).
- More risk associated with lower risk-free rate ($\gamma < 0$).

5. Findings: risk vs. state debt, rates, and FR, panel

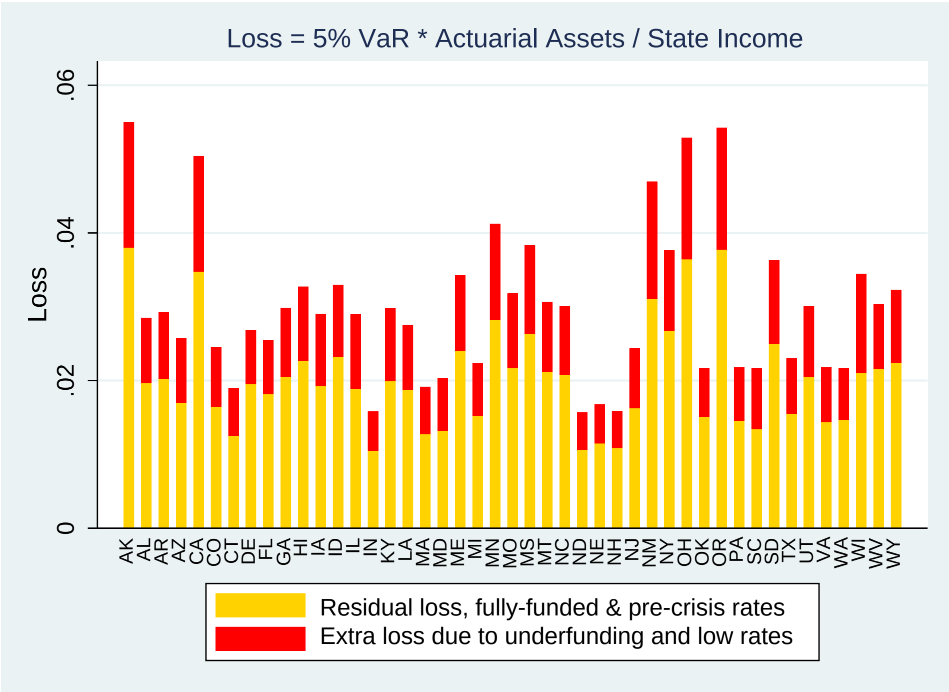
- $Risk_{pt} = \alpha + \beta * State_{pt} + \gamma * TrYield_t + \delta * State_{pt} * TrYield_t + \varepsilon_{pt}$
- $Risk_{pt} = \alpha + \beta * State_{pt} + \gamma' * FR_p + \delta' * State_{pt} * FR_p + \varepsilon_{pt}$

Dependent variable:	(1) Conditional VaR	(2) Conditional VaR	(3) Conditional VaR	(4) Conditional VaR	(5) Conditional VaR	(6) Conditional VaR
State debt/income	0.027***	0.0095***	0.0054			
	(0.0011)	(0.0011)	(0.017)			
State bond rating				0.0015***	0.0012***	0.0013**
				(0.00020)	(0.000056)	(0.00049)
1 yr Tr yield	-0.018**	-0.018**	-0.018**	-0.018**	-0.018**	-0.018**
	(0.0074)	(0.0074)	(0.0076)	(0.0068)	(0.0068)	(0.0067)
1 yr Tr Yield * State debt/income	-0.010**					
	(0.0033)					
1 yr Tr Yield * State bond rating				-0.00039***		
				(0.000090)		
FR fixed	-0.021***	-0.030***		-0.017***	-0.018***	
	(0.0017)	(0.0016)		(0.0013)	(0.0014)	
FR fixed * State debt/income		0.77***				
		(0.00013)				
FR fixed * State bond rating					0.021***	
					(0.0038)	
FR (t-1)			-0.017*			-0.020***
			(0.0078)			(0.0024)
FR (t-1) * State debt/income			0.20			
			(0.18)			
FR (t-1) * State bond rating						0.028***
						(0.0070)

- More risk associated with worse state finances ($\beta > 0$), with low rates ($\delta < 0$).
  - Consistent with **risk-shifting**.
- The interaction between state finances and FR is positive ($\delta' > 0$).
  - Result consistent with **no risk-shifting**.

5. Materiality of risk-taking for finances.

- Using panel regression results we estimate total losses to state finances if PPFs' losses = 5% VaR in two hypothetical cases:
    1. During 2016, PPFs are fully funded pre-crisis interest-rates. (yellow)
    2. During 2016, underfunded with low rates (red + yellow)
- Underfunding and low rates accounted for 1/3 of total risk in 2016 (Panel B).



Conclusions

- We document the risk-taking behavior of U.S. public pension funds:
    - Risk-taking is related to underfunding, low interest rates on safe assets, sponsor finances.
- We use an innovative econometric approach:
    - Value at risk approach for inferring PPFs' risk.
    - Estimate funds category-risk exposures.
    - Adjust actuarial measures of liabilities using a risk-free discount-rate.
- Underfunding and low risk-free rates accounted for about 1/3 of the PPFs' total risk measured by 5%-VaR in 2016.
- **More research is needed on how sponsor's finances affect risk-taking**.