Pension Reform and Asset Allocation

Evidence from Annuity Cuts to Retired Civil Servants in Taiwan

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NBER SI Economics of Social Security

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Pension Reform Worldwide

- Pension reform is a central issue in aging societies (Lindbeck and Persson, 2003; OECD, 2019, 2021, 2023).
- U.S. Social Security's retirement trust fund is projected to be depleted around 2032.
- Reform is widely anticipated, but the policy response is uncertain: higher payroll taxes, a higher retirement age, or benefit cuts?

Why Taiwan?

- Taiwan's 2017 pension reform for civil servants was a large-scale regulatory change.
- Pension replacement rates cut by 27.5–45 p.p.
- Unexpectedly retroactive: it applied to retirees already receiving benefits.
- Retroactive reform + defined benefit pension syste

$$\Longrightarrow \textbf{Exogenous permanent income shock to retirees}$$

Theoretical Motivation

- Risky asset investment is a core question in household finance (Campbell, 2006; Beshears et al., 2018; Gomes, Haliassos, and Ramadorai, 2021).
- Permanent income/human capital shapes households' lifetime resources and portfolio choices (Campbell, 2006; Gomes, 2020).
- Causal inference is challenging: measurement & exogenous variation
- For retirees, pension income is a major component of lifetime resources.
- **Research Question:**
  How does a pension-reform-induced permanent income reduction affect retirees' asset allocation?

Preview of Results

In comparison with retirees in the private sector, retired civil servants revealed the following patterns:

- stock-to-wealth ratio $\uparrow$ by about 11%
- stock holdings $\uparrow$ by about 6.5%
- active rebalancing is concentrated in the first two years
- point estimates are larger for families with more children
- deposits-to-wealth ratio $\downarrow$ by about 25%
- Additional trading patterns: (1) chasing high-return stocks; (2) realized gains increase more than realized losses.

Prospect Theory Intuition

- Sure loss: $(-\$500, 1)$ vs. Gamble: $(-\$1000, \frac{1}{2};\ 0, \frac{1}{2})$
- Pension Income $\downarrow$ vs. Pension Income $\downarrow$ + Equity Exposure $\uparrow$

Contribution

1. The impacts of pension reforms and retirement savings (Feldstein, 1974; Krueger and Meyer, 2002; Attanasio and Brugiavini, 2003; Fisher and Keuschnigg, 2010; Beshears et al., 2011; Choi, 2015; Poterba, Venti, and Wise, 2011; Scharfstein, 2018; Zhang and Sialm, 2025)
   - Retroactive pension cuts are uncommon.
   - Most prior studies focused on saving rates/contribution rates and incentivizing late retirement.
   - We focus on risky asset allocation.
2. The determinants of stock market participation and risky asset holdings (Campbell, 2006; Curcuru et al., 2010; Gomes, 2020)
   - Challenge the common belief and empirical results of a positive relation between risky asset holdings and permanent income (Merton, 1971; Viceira, 2001; Cocco, Gomes, and Maenhout, 2005; Calvet and Sodini, 2014)
3. New empirical evidence of prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992; Kőszegi and Rabin, 2006; Kőszegi and Rabin, 2007; Abdellaoui et al., 2008; Harbaugh et al., 2010; Page, Savage, and Torgler, 2014; Lian, Ma, and Wang, 2019)
   - Prior evidence is mostly from experimental settings.

Agenda

1. Introduction
2. Background
3. Data
4. Identification Design and Main Results
5. Mechanism
6. Additional Behavioral Biases
7. Conclusion

Pension Calculation: Income Replacement Ratio

Table 1: Income Replacement Ratio Before and After the Pension Reform

Tenure	40	**35**	30	25	20	15
(A)	95%	95%	85%	75%	75%	75%
(B)	90%	90%	90%	85%	80%	75%
July, 2018	77.5%	75.0%	67.5%	60.0%	52.5%	45.0%
2029	62.5%	60%	52.5%	45%	37.5%	30%

Example: tenure 35, middle-ranked retiree: **\$25,444** $\rightarrow$ **\$21,203** $\rightarrow$ **\$16,963**.

- Two possible schemes pre-reform (A/B).
- Legislation passed in 2017.
- Pension cuts started in July 2018.
- Additional 1.5% decrease every year until 2029.

Go to details

Data

Tax Record Data

- Asset data: including deposits, bonds, stocks, housing, land, and car ownership.
- Taxable salary, income from professional practice, bonuses, dividends, interest, and other personal income items.
- Employer-employee linkage.

Household Registration Data

- Demographic variables: the ID, the ID of spouse and children, gender, birth date, death date, and marital status.

Taiwan Economic Journal (TEJ) Data

- Firm-level information: stock prices, outstanding shares, trading volumes, etc.
- Market returns.

Sample Construction

- Panel Data: 2013-2021
- Single-earner families among retirees
- The single-earner retired between 2011 and 2016.
- Husbands aged between 55 and 70 years old.
- Treated: Retired Civil Servants; Control: Private Sector Retirees

Summary Statistics

Table 2: Summary Statistics in the Pre-Event Period (2013-2016)

	Population	Civil Servant	Private Sector
Husband Age	60.75	61.41	60.65
Wife Age	57.45	58.39	57.31
Male Breadwinner	0.732	0.860	0.713
Child Dependency	0.317	0.278	0.323
Deposit (thousands)	3,313.4	4,407.3	3,151.0
Bond (thousands)	2.512	0.430	2.820
Stock Holdings (thousands)	2,099.4	1,242.1	2,226.7
Conditional Stock Holdings (thousands)	3,079.0	1,727.8	3,291.1
SMP	0.678	0.713	0.673
Present Value of Cars (thousands)	151.2	155.2	150.6
Assessed Value of Real Estate (thousands)	10,964.9	10,351.7	11,055.9
Owning Real Estate	0.903	0.948	0.897
Mortgage (thousands)	295.6	266.9	299.8
Total Wealth (thousands)	16,531.4	16,156.7	16,587.0
Deposit/Wealth	0.180	0.238	0.171
Stock/Wealth	0.115	0.079	0.121
Observations	434,441	56,147	378,294

Identification Design: Difference-in-Differences

We estimate the following DiD regression using a household-year panel:

$$\text{AssetAllocation}_{it} = b\,\text{CivilServant}_i \times \text{Post}_t + \mathbf{X}_{it}\Gamma + \mathbf{B}'_{i,2016}\Lambda_t + \mu_i + \delta_t + \varepsilon_{it}.$$

- Main dep. var.: ln (Stock/Wealth) & ln(Stock Holdings)
- CivilServant_i: indicator for whether the income earner was a civil servant.
- Post_t: post-reform dummy ($t \geq 2017$).
- $\mathbf{X}_{it}$: time-varying controls, including # of children ≤ 24 yrs old, $\ln(1 + \text{mortgage})$, and fixed effects for the husband's age. Γ is the corresponding coefficient vector.
- $\mathbf{B}'_{i,2016}\Lambda_t$: baseline controls interacted with year dummies. The controls, all measured in 2016, include $\ln(1 + \text{Wealth})$, $\ln(1 + \text{Deposits})$, active rebalancing (A), passive valuation (P), and excess return.
- μ_i: household fixed effects.
- δ_t: year fixed effects.

Stock-to-wealth Ratio

Table 3: Effect of Pension Reform on the Stock-to-Wealth Ratio

	(1)	(2)	(3)
	ln(Stock/Wealth)		
Civil Servant X Post	0.119***	0.115***	0.110***
	(0.0103)	(0.0103)	(0.0104)
Child Dependency		-0.00243	-0.00112
		(0.00633)	(0.00632)
ln(1+mortgage)		0.0213***	0.0201***
		(0.000485)	(0.000488)
Household FE	Y	Y	Y
Year FE	Y	Y	Y
Husband Age FE	-	Y	Y
Baseline Controls × Year Indicators	-	-	Y
Observations	727,959	727,959	726,066
R-squared	0.0161	0.0220	0.0305

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are clustered at household level.

→ Retired civil servants increase their stock-to-wealth ratio by about 11% after reform

Event-Study: Stock-to-Wealth Ratio

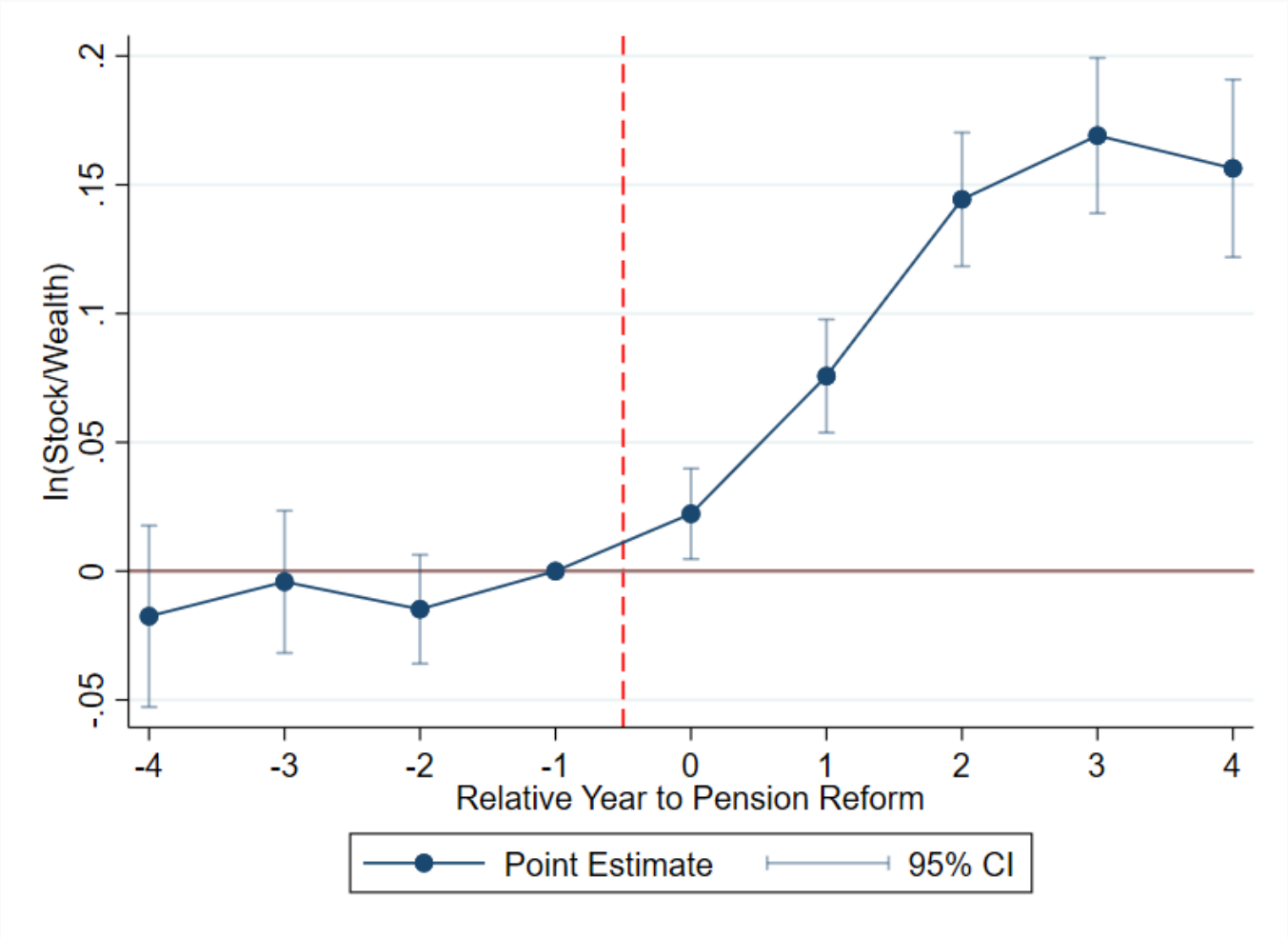


Figure 1: Logarithm of stock-to-wealth ratio in different years

Power test

Stock Holdings

Table 4: Effect of Pension Reform on Stock Holdings

	(1)	(2)	(3)
	ln(Stock Holdings)		
Civil Servant X Post	0.0718***	0.0755***	0.0654***
	(0.00997)	(0.00999)	(0.0101)
Child Dependency		-0.0111*	-0.0118*
		(0.00625)	(0.00626)
ln(1+mortgage)		-0.000484	-0.000664
		(0.000439)	(0.000444)
Household FE	Y	Y	Y
Year FE	Y	Y	Y
Husband Age FE	-	Y	Y
Baseline Controls × Year Indicators	-	-	Y
Observations	731,098	731,098	727,941
R-squared	0.0138	0.0142	0.0186

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are clustered at household level.

→ Retired civil servants increase their stock holdings by about 6.5% after reform

Event Study: Stock Holdings

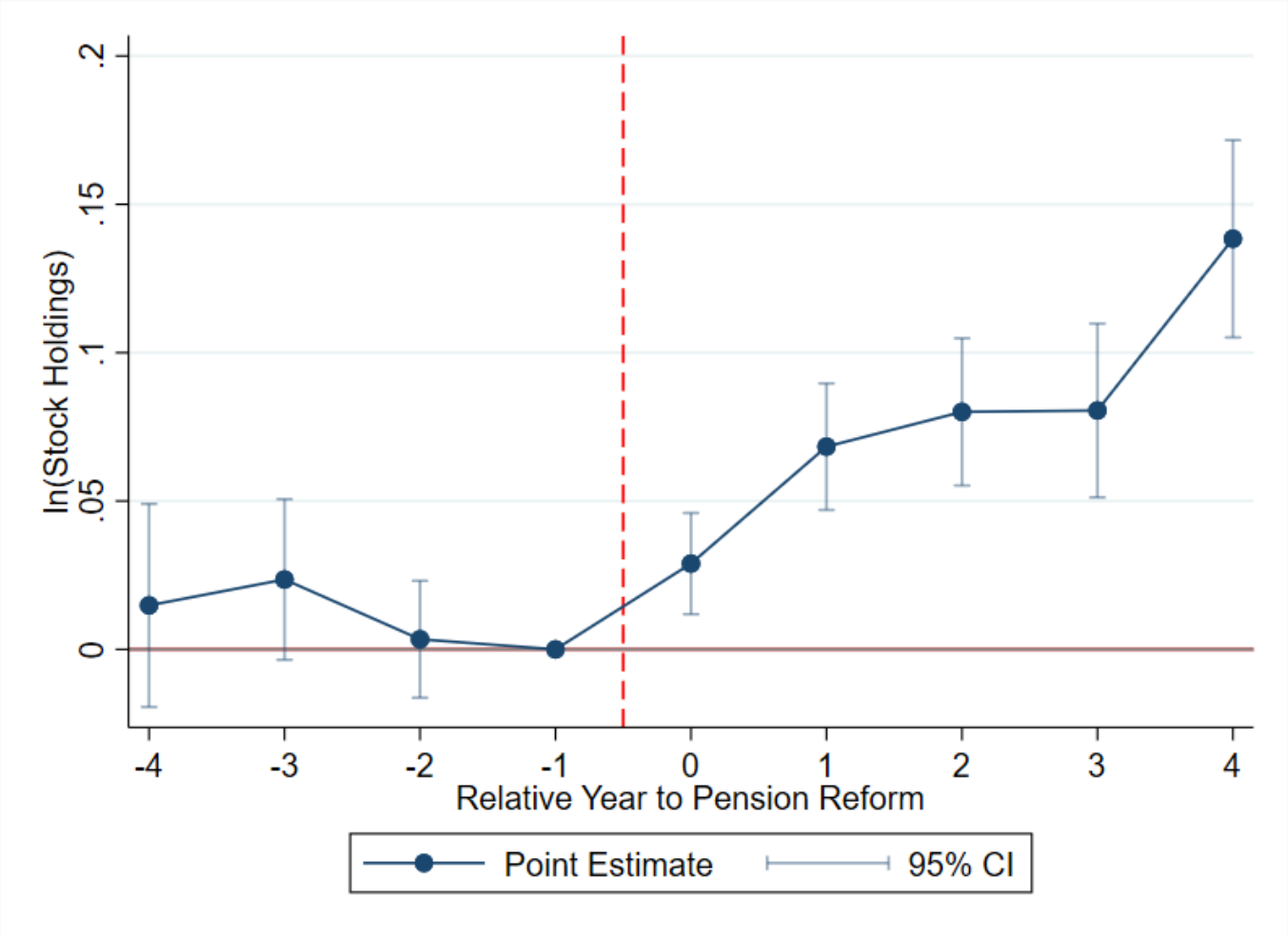


Figure 2: Logarithm of stock holdings in different years

Power test

Robustness Checks

Our results are robust to:

- Potential pre-trend — Power test
- Shift-out of preferential deposits — Preferential Deposits
- Matched sample based on pre-reform observables — Matched Sample

Separating Active Rebalancing and Passive Valuation

- Construct the "no-trade counterfactual" (Calvet, Campbell, and Sodini, 2009).
- Hold the time-t portfolio fixed and ask: what would the time-$t+1$ stock-to-wealth ratio be without trading?
- Compare the observed ratio, $w_{i,t+1}$, with its passive no-trade counterpart, $w^p_{i,t+1}$.
- Active rebalancing is

$$a_{i,t+1} = \ln w_{i,t+1} - \ln w^p_{i,t+1} = \ln \left(\frac{w_{i,t+1}}{w^p_{i,t+1}} \right).$$

Construction details

Event Study: Active Rebalancing

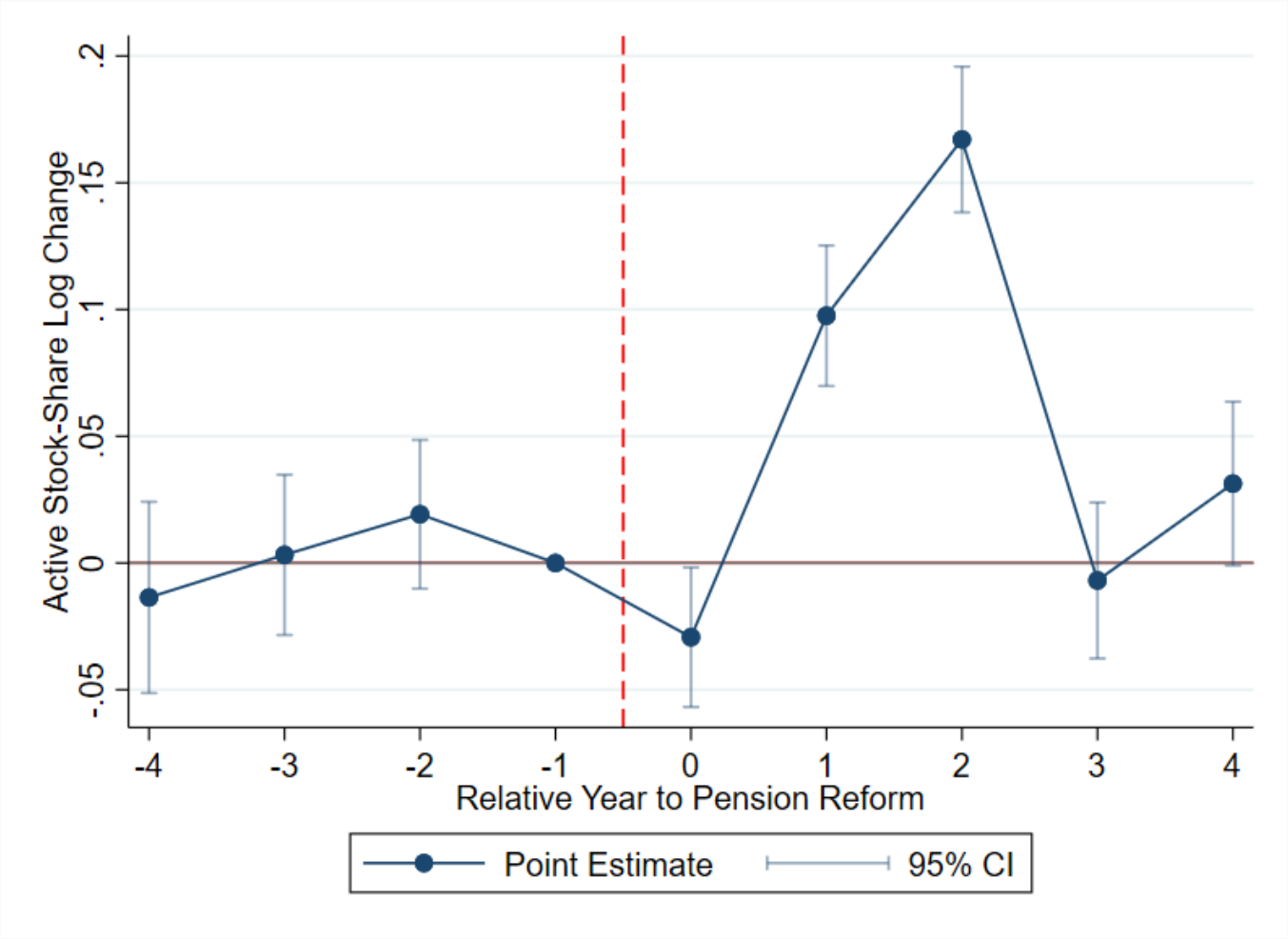


Figure 3: Active Log Stock-to-Wealth Change

$\rightarrow$ The reform raised the observed stock-to-wealth ratio about 10% and 18% above its no-trade benchmark in the first two implementation years.

A rational asset allocation adjustment?

1. **Optimal Portfolio Choice with riskless labor income** (Merton, 1971)

$$\alpha = \left[1 + \frac{PV(Y)}{W}\right] \frac{\mu - r}{\gamma\sigma^2}$$

2. **Habit Persistence model** (Brunnermeier and Nagel, 2008; Calvet and Sodini, 2014)

$$\alpha = \left[1 + \frac{PV(Y) - \lambda X}{W}\right] \frac{\mu - r}{\gamma\sigma^2}$$

Under both models,

$$\frac{\partial \alpha}{\partial PV(Y)} = \frac{1}{W} \frac{\mu - r}{\gamma\sigma^2} > 0.$$

$\rightarrow$ A reduction in pension income should lead civil servants to *decrease* their stock-to-wealth ratios following the pension reform

Prospect Theory Interpretation

- Individuals evaluate outcomes relative to a **reference point** and exhibit **asymmetric risk preferences** (Kahneman and Tversky, 1979).
- The pre-reform consumption habits served as a salient **reference point** (Kőszegi and Rabin, 2006; Kőszegi and Rabin, 2007).
- The reform generated a **perceived loss**.
- In the loss domain, civil servants became risk-seeking.
- The chance to "break even" is psychologically appealing. Toy Model

Testing prospect theory:

- Heterogeneity based on financial pressure.
- Higher financial pressure $\rightarrow$ higher perceived loss
- Child-raising loads

Child-raising Loads

Table 5: Subgroup Analysis based on Child-raising Loads

	(1)	(2)	(3)
Number of Children	0	1	≥ 2
Panel A: ln(Stock/Wealth)			
Civil Servant X Post	0.100***	0.128***	0.167***
	(0.0114)	(0.0337)	(0.0626)
Observations	602,735	86,569	36,762
Panel B: ln(Stock Holdings)			
Civil Servant X Post	0.0626***	0.0950***	0.103*
	(0.0110)	(0.0338)	(0.0606)
Observations	604,322	86,775	36,844
Household FE	Y	Y	Y
Year FE	Y	Y	Y
Husband Age FE	Y	Y	Y
Baseline Controls $\times$ Year Indicators	Y	Y	Y

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are clustered at household level.

Other Financial Behavior

Table 6: Effect of Pension Reform on Other Financial Behavior

	(1) SMP	(2) ln(1+Real Estate)	(3) ln(Deposit/ Wealth)	(4) ln(1+Total Wealth)
Civil Servant X Post	0.00588***	-0.000770	-0.247***	-0.0375***
	(0.00129)	(0.0117)	(0.00723)	(0.00804)
Household FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Husband Age FE	Y	Y	Y	Y
Baseline Controls × Year Indicators	Y	Y	Y	Y
Observations	1,110,056	1,100,965	604,871	1,106,355

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are clustered at household level.

Chasing Stocks with High Past Return

Table 7: Effect of Pension Reform on Past Excess Returns

	(1)	(2)	(3)
	Past Excess Return	Past Excess Return	Past Excess Return
Civil Servant X Post	0.863***	0.882***	0.581***
	(0.199)	(0.199)	(0.179)
Child Dependency		-0.431***	-0.407***
		(0.134)	(0.129)
ln(1+mortgage)		0.0102	0.00347
		(0.0117)	(0.0113)
Household FE	Y	Y	Y
Year FE	Y	Y	Y
Husband Age FE	-	Y	Y
Baseline Controls × Year Indicators	-	-	Y
Observations	731,098	731,098	727,941

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are clustered at household level.

Disposition Effect

Table 8: Effect of Pension Reform on realized gains and losses (from stocks sold)

	(1)	(2)	(3)
Panel A: ln(1+Realized Gains)			
Civil Servant X Post	0.175***	0.216***	0.0999***
	(0.0327)	(0.0324)	(0.0326)
Panel B: ln(1+Realized Losses)			
Civil Servant X Post	0.0468*	0.0798***	0.0328
	(0.0278)	(0.0277)	(0.0279)
Household FE	Y	Y	Y
Year FE	Y	Y	Y
Husband Age FE	-	Y	Y
Baseline Controls × Year Indicators	-	-	Y
Observations	731,098	731,098	727,941

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are clustered at household level.

Conclusion

- We examine how retired civil servants change their asset allocation upon an unexpected annuity cut.
- Retired civil servants increased their stock-to-wealth ratios by about 11% and their stock holdings by about 6.5%.
- Our study provides novel evidence on the effect of permanent income reduction on portfolio choices.
- Consistent with prospect theory: point estimates are larger for families with more children, and realized gains increase more than realized losses.
- Policy implications: (1) household investment risk and social security; (2) spillover effects on the defined contribution system; (3) reduced incentives to serve in the public sector.

Pension Prior to the Reform

Broadly, a civil servant's monthly income is composed of four primary components: (1) Base Salary (2) Professional Allowance (3) Position Allowance (4) Remote Area Allowance.

- Income replacement ratio is determined by tenure.
- Monthly pension is determined by tenure and pre-retirement salary.
- Preferential interest makes up the difference.
- A unique deposit account with 18% annual interest (capped).
- The civil servant's pension is determined by the plan offering the lower preferential interest.
- Plan (A) is designed for higher-ranked officers.
- Plan (B) caters to elementary civil servants.
- A minimum of approximately 75%, with the potential to reach up to 95%.

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Pension Prior to the Reform

Two distinct formulas for income replacement ratios:

(A)

$$\frac{\text{Monthly Pension} + \text{Preferential Interest}}{\text{Base Salary} \times 2} = 75\% + 2 \times (\text{Tenure} - 25)\%,$$

where individuals with tenure below 25 years are assigned 25 years, and tenure is capped at 35 years.

(B)

$$\frac{\text{Monthly Pension} + \text{Preferential Interest}}{\text{Base Salary} + \text{Professional Allowance} + \text{Position Allowance} + \frac{\text{Year-end Bonus}}{12}} = 75\% + (\text{Tenure} - 15)\%,$$

where individuals with tenure below 15 years are assigned 15 years, and tenure is capped at 30 years.

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Post-reform Pension Calculation

$$\frac{\text{Monthly Pension} + (\text{Preferential Interest})}{\text{Average Base Salary} \times 2}$$

$$= \begin{cases} 45\% & +(\text{Tenure} - 15) \times 1.5\% - \min\{\text{Year} - 2019, 10\} \times 1.5\% \\ & \text{if Tenure} \leq 35 \\ 75\% & +(\text{Tenure} - 35) \times 0.5\% - \min\{\text{Year} - 2019, 10\} \times 1.5\% \\ & \text{if Tenure} \geq 35 \end{cases}$$

- The "average base salary," initially calculated as the average base salary of the last five years starting from June 2018, gradually extends to the average base salary of the last 15 years by 2029.
- Floor of pension: 33,140 NTD
- 2017: 18%; July, 2018-2020: 9%

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No-Trade Counterfactual Construction (I)

- The stock share is

$$w_{i,s,t} = \frac{S_{i,s,t}}{\sum_s S_{i,s,t}}.$$

- Holding the time-t portfolio fixed, the passive stock return is

$$1 + r^p_{i,t+1} = \sum_s w_{i,s,t} \left(1 + r_{s,t+1}\right).$$

- Assuming other household wealth X remains constant, the passive stock-to-wealth ratio is

$$w^p_{i,t+1} = \frac{S_{i,t}(1 + r^p_{i,t+1})}{S_{i,t}(1 + r^p_{i,t+1}) + D_{i,t}(1 + r_{f,t+1}) + X_{i,t}}.$$

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No-Trade Counterfactual Construction (II)

- The observed change can be decomposed into active rebalancing and passive valuation:

$$\begin{aligned} w_{i,t+1} - w_{i,t} &= (w_{i,t+1} - w^p_{i,t+1}) + (w^p_{i,t+1} - w_{i,t}) \\ &= A_{i,t+1} + P_{i,t+1}. \end{aligned}$$

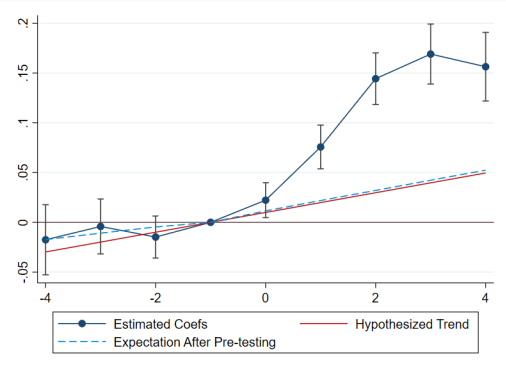
- In logs,

$$a_{i,t+1} = \ln w_{i,t+1} - \ln w^p_{i,t+1} = \ln \left(\frac{w_{i,t+1}}{w^p_{i,t+1}} \right),$$

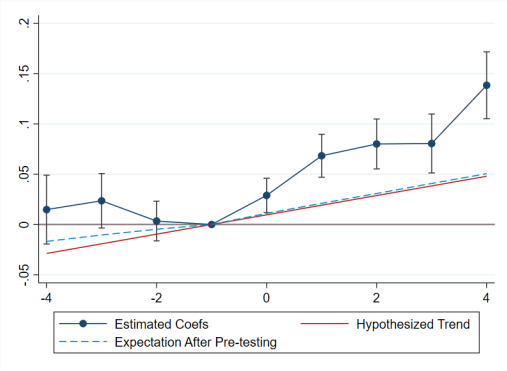
$$p_{i,t+1} = \ln w^p_{i,t+1} - \ln w_{i,t} = \ln \left(\frac{w^p_{i,t+1}}{w_{i,t}} \right).$$

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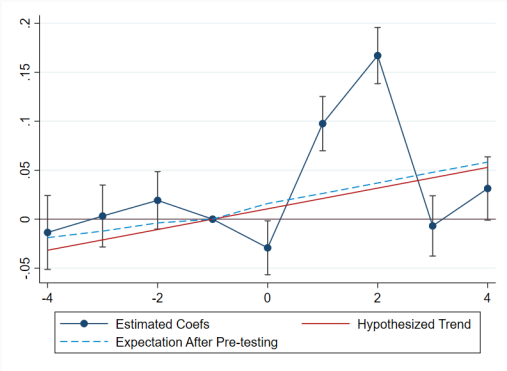
Power test (Roth, 2022)



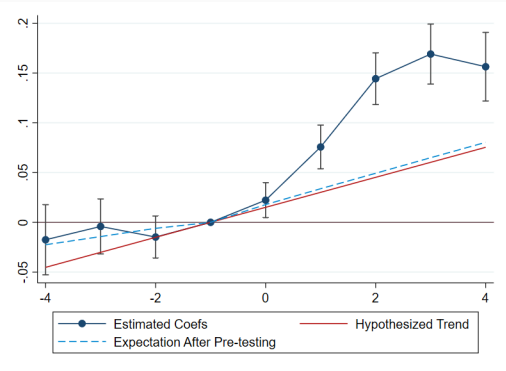
(a) ln(Stock/Wealth); Power: 0.5



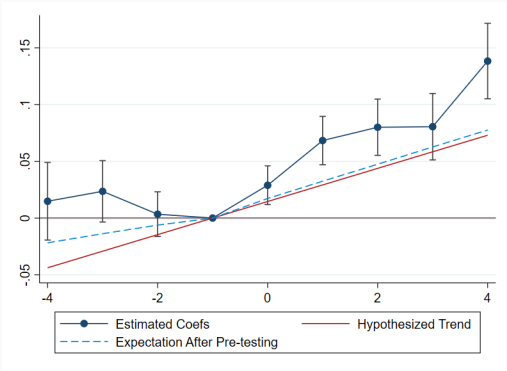
(b) ln(Stock Holdings); Power: 0.5



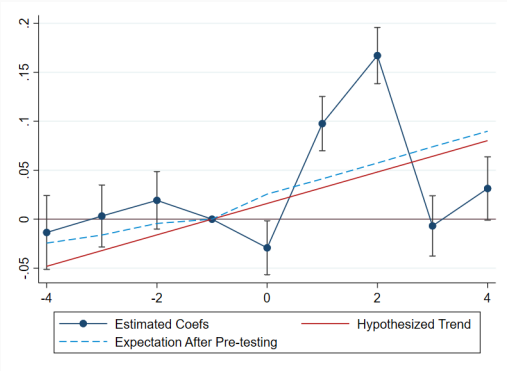
(c) Active Rebalancing; Power: 0.5



(d) ln(Stock/Wealth); Power: 0.8



(e) ln(Stock Holdings); Power: 0.8



(f) Active Rebalancing; Power: 0.8

Figure 4: Robustness Check for Pre-trend Testing

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Ruling Out Preferential Deposits

Table 9: Robustness Check: Preferential Deposits

	(1) Preferential Deposits	(2) Preferential Deposits	(3) Implied Stock Holdings Changes
Year = 2013	18233.2***	-29515.3**	25,571.4
	(3229.3)	(14148.8)	
Year = 2014	12842.4***	-23630.6**	40,776.1
	(2237.8)	(10691.2)	
Year = 2015	8409.4***	-21536.5***	5,891.8
	(1499.8)	(6308.9)	
Year = 2017	-3798.2***	-5200.0	49,933.4
	(1147.4)	(4411.9)	
Year = 2018	-31641.0***	-24122.1***	118,008.7
	(1801.0)	(6513.8)	
Year = 2019	-119964.5***	-77933.9***	138,224.0
	(4049.9)	(13175.5)	
Year = 2020	-173902.8***	-49612.2***	139,087.9
	(3972.5)	(12068.6)	
Observations	128888	128350	727941

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors are clustered at household level.

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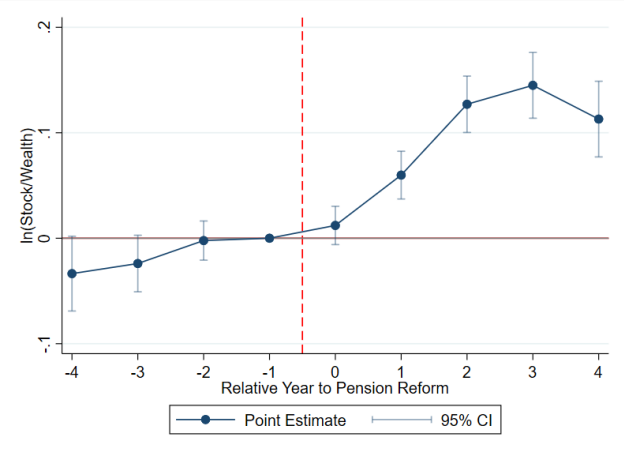
Table 10: Summary Statistics for Matched Sample

	Civil Servants	Private Sector	Difference
Husband Age	62.10	61.95	-0.15***
Wife Age	59.06	58.88	-0.18***
Male Breadwinner	0.86	0.86	-0.00
Child Dependency	0.25	0.25	-0.01
Deposit (thousands)	4,219.61	4,304.05	84.45
Bond (thousands)	0.05	0.68	0.63**
Stock Holdings (thousands)	1,195.06	1,330.74	135.68**
Conditional Stock Holdings (thousands)	1,704.32	1,875.09	170.76**
SMP	0.70	0.71	0.01*
Present Value of Cars (thousands)	152.23	154.37	2.14
Assessed Value of Real Estate (thousands)	10,959.83	10,776.27	-183.56
Owning Real Estate	0.95	0.97	0.02***
Mortgage (thousands)	287.09	254.17	-32.92**
Total Wealth (thousands)	16,526.78	16,566.12	39.34
Deposit/Wealth	0.23	0.22	-0.01**
Stock/Wealth	0.07	0.08	0.00
Observations	20,535	60,347	80,882

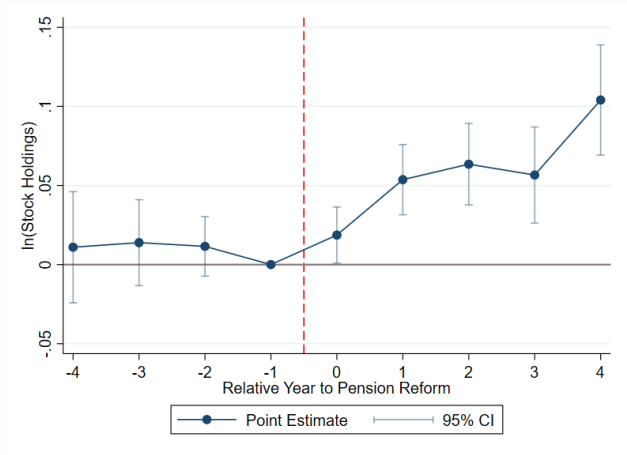
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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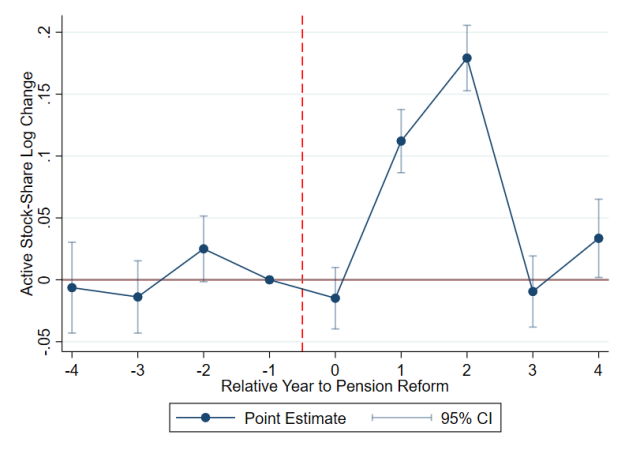
Matched Sample Results



(a) ln(Stock/Wealth)



(b) ln(Stock Holdings)



(c) Active Rebalancing

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A Simple Reference-Dependent Portfolio Choice Model (I)

Setup. A retiree has baseline deposits and stocks (D_0, S_0). The promised pension falls from P_0 to $P < P_0$. The pre-reform consumption plan is the reference point:

$$\bar{C} = P_0 + D_0 + S_0.$$

If the retiree keeps marginal savings in deposits, safe post-reform consumption is

$$C^S = P + D_0 + S_0, \qquad G \equiv \bar{C} - C^S = P_0 - P > 0.$$

The retiree reallocates $a \in [0, \bar{a}]$ dollars from deposits into stocks. Let X be the stock's excess payoff relative to deposits. Then

$$C(a, X; P) = C^S + aX, \qquad C(a, X; P) - \bar{C} = -G + aX.$$

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A Simple Reference-Dependent Portfolio Choice Model (II)

Reference-dependent utility.

$$u(C) = \begin{cases} C - \bar{C}, & C \geq \bar{C}, \\ -\lambda(\bar{C} - C), & C < \bar{C}, \end{cases} \qquad \lambda > 1.$$

The retiree solves

$$\max_{a \in [0, \bar{a}]} U(a, G) \equiv \mathbb{E}[u(C(a, X; P))].$$

Assumption. (Lian et al, 2018.) The excess payoff is binary and satisfies

$$X = \begin{cases} g > 0, & \text{with probability } p, \\ -\ell < 0, & \text{with probability } 1 - p, \end{cases} \qquad pg > (1-p)\ell \quad \text{and} \quad pg < \lambda(1-p)\ell.$$

Then

$$\boxed{a^* = \frac{G}{g} = \frac{P_0 - P}{g}.}$$

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