Pension Reform and Asset Allocation: Evidence from Annuity Cuts to Retired Civil Servants in Taiwan*

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Abstract

We examine the asset allocation effect of a *retroactive* pension cut in Taiwan that specifically affected retired civil servants. Following the reform, these retirees increased their stock-to-wealth ratios by 11.0% and their stock holdings by 6.54%. Their active adjustment increased by 4.65% on average and was concentrated in the first two post-reform years. This response is consistent with a break-even motive under reference-dependent utility rather than conventional Merton-style portfolio choice. We also find larger point estimates among households with more dependent children and greater pre-reform financial resources. Retired civil servants also reallocated toward stocks with higher past realized risk premiums and increased selling activity primarily among positions with gains.

Keywords: pension reforms; retirement saving; permanent income shock; stock market participation; asset allocation; prospect theory; household finance.
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1 Introduction

The allocation of household assets—particularly the share invested in risky ones—has been a core research topic in household finance (Campbell, 2006; Beshears et al., 2018; Gomes et al., 2021; Campbell and Ramadorai, 2026). Holdings of risky assets vary with characteristics such as age, gender, health, income, and wealth (Rosen and Wu, 2004; Curcuru et al., 2010; Addoum, 2017; Choi and Robertson, 2018). Among these characteristics, permanent income plays a particularly important role because it determines households' lifetime resources (Campbell, 2006; Gomes, 2020).

However, because permanent income depends on many factors and is difficult to measure, drawing causal inferences about its effect on asset allocation is difficult. We address this challenge by focusing on retirees, whose income sources are limited and for whom pension benefits constitute a major component of permanent income (De Nardi et al., 2025).[1] Population aging has increased pension obligations across countries, triggering pension reforms that have already reduced benefits and foreshadowing further reforms and benefit cuts in the years ahead (Lindbeck and Persson, 2003; OECD, 2019, 2021, 2023; Coile et al., 2025). In the United States, for example, the Old-Age and Survivors Insurance Trust Fund is projected to deplete its reserves in the fourth quarter of 2032 (Social Security Board of Trustees, 2026). Despite the pressing and long-lasting implications of these reforms for household financial decisions, there is limited evidence on how pension reforms affect asset allocation behavior (Bottazzi et al., 2006; Scharfstein, 2018; Zhang, 2021).[2]

The theoretical and empirical literature offers *opposing* predictions for the effect of pension reforms on retirees' asset allocation. On the one hand, standard life-cycle portfolio choice models predict that retirees reduce their exposure to risky assets following pension

[1] Agarwal et al. (2025) study consumption responses to a permanent increase in income from retirement support among low-income elderly households in Singapore.

[2] This gap in the literature can be attributed to (i) the lack of an appropriate identification strategy and (ii) limited data on households' total wealth and asset allocation. Moreover, most reforms target the entire population or impose gradual changes over extended periods, making it difficult to design a credible identification strategy.

cuts. In particular, Merton (1971), Viceira (2001), and Calvet and Sodini (2014) imply that the optimal risky share declines in response to negative permanent income shocks. This theoretical prediction is supported by the empirical evidence of Cocco et al. (2005) and Calvet and Sodini (2014). On the other hand, a growing body of empirical research documents pervasive behavioral patterns in households' financial decisions that deviate from the predictions of standard economic models (Odean, 1998, 1999; Beshears et al., 2018; Stango and Zinman, 2022; Olafsson and Pagel, 2024, 2025). According to prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992), outcomes below a salient reference point can generate a break-even motive: individuals may take greater financial risk for a chance to narrow or eliminate a loss. Consistent with this motive, prior studies show that losses and difficult-to-reach goals can lead individuals to take greater financial risk (Page et al., 2014; Lian et al., 2018; Gomes et al., 2025; Arkolakis et al., 2026). If a similar motive operates in the context of pension reforms, retirees facing pension cuts relative to their pre-reform living standards may increase their allocations in risky assets.

To empirically test these opposing predictions, we exploit one of the most radical pension reforms in recent history—the pension reform of civil servants in Taiwan in 2017—together with comprehensive administrative data on household assets. Under the reform schedule, income replacement ratios (i.e., annuity income relative to pre-retirement income) that had ranged from 75% to 95% before the reform were substantially reduced in July 2018 and were scheduled to decline further to a range of 30% to 62.5% by 2029. Importantly, retirees outside the public sector were unaffected during the reform period.

Two key features of this reform are noteworthy. First, the legislation was passed within 13 months of the establishment of a special pension reform committee in May 2016. Second, it was applied *retroactively* to civil servants who had already retired and were receiving monthly pension benefits at the time of implementation. It therefore reduced benefits that had already been promised to existing retirees, departing from the usual practice of grandfathering accrued pension benefits. Because civil-servant pensions in Taiwan operate under

a defined-benefit (DB) system and are paid as predictable monthly annuities, the reform induced an unexpectedly deep cut to retired civil servants' permanent income. This institutional setting allows us to study households' financial responses to a negative permanent income shock without relying on strong structural assumptions typically required to infer permanent income from short panels of realized labor income (Cocco et al., 2005; Calvet and Sodini, 2014).

There are several important institutional features of civil servants in Taiwan. First, civil servants constitute a significant portion of employment in Taiwan. In 2017, there were 912,451 civil servants at work, accounting for 8% of total employees. Second, being a civil servant was regarded as a stable job with a high entry barrier. Individuals who intend to serve in the government must pass rigorous examinations (the pass rate was only 9.31% in 2016) and corresponding training programs to qualify. After they are formally recruited, civil servants are rarely laid off due to poor performance or government restructuring, although elimination mechanisms do technically exist. In 2020, the turnover rate of civil servants was only 0.68%. Finally, civil servants receive retirement annuities after they retire, which are determined based on their tenure and pre-retirement salary levels.[3] Before the pension reform in 2017, such annuities were considered generous.

To compile the data on households' asset allocation, we rely on several administrative tax-related databases from the Fiscal Information Agency (FIA) of the Ministry of Finance, Taiwan. These databases cover individuals' income and wealth in six asset categories: buildings, land, stocks, bank deposits, bonds, and cars. The underlying administrative records span 2001 to 2021, and our analysis panel covers 2013 to 2021.

We design a difference-in-differences setting to examine whether retired civil servants

[3]Although retired civil servants can choose to cash out their pension in a lump sum upon retirement (which is irreversible), such an option is rarely exercised (fewer than 2% in 2016). The cash-out option is often chosen by individuals who left the civil service much earlier than regular retirement age and/or were not eligible for annuities due to insufficient tenure. As our sample focuses on retirees whose retirement decision occurred before the reform, our analysis is not subject to these retirees' annuitization decisions. Also, there is only one pension account for civil retirees, so we are not subject to the cross-account annuitization discussed in Hurwitz and Sade (2025).

react differently from other retirees to the pension reform with respect to asset allocation. We focus on households with only one working individual who retired before the pension reform,[4] and then divide our observations into two groups: those retiring as civil servants and those retiring from the private sector (as our treatment and control groups, respectively). In this setting, individuals' retirement decisions were not affected by the pension reform, and their annuities and pension plans are fixed and thus not subject to uncertainty absent the pension cuts.

To measure a household's risky asset allocation, we focus our analysis on stock portfolios for several institutional reasons. First, it is common in the household finance literature to use stock holdings to proxy for risky assets (Calvet and Sodini, 2014; Addoum, 2017; Zhang, 2021; Gomes et al., 2025). Second, stocks are the most common and accessible class of risky asset for households in Taiwan. Third, unlike in the United States, Taiwan does not impose capital gains taxes on stock investments (but does impose a 0.3% transaction tax), which allows retired civil servants to adjust their portfolios without incurring taxes from short-term capital gains. As a result, concerns about tax-loss harvesting, tax-swap, and tax-induced trading distortions are largely absent in our research.

We use the total value of stock holdings and the stock-to-wealth ratio to measure a household's exposure to risky assets (Calvet and Sodini, 2014; Addoum, 2017; Zhang, 2021; Gomes et al., 2025). These measures do not require us to estimate portfolio risk, and they are closely related to the risky asset demand studied in theoretical portfolio choice models (Merton, 1971; Viceira, 2001).[5] We find that, relative to other retirees, retired civil servants increase their stock-to-wealth ratios by 11.0% and their stock holdings by 6.54% after the reform. Using the no-trade counterfactual of Calvet et al. (2009), we separate

[4]Households with only one working individual are dominant in our retiring household population (75%). As the primary breadwinners in the sample are predominantly husbands, we further refine the sample to include only those whose husbands are between 55 and 70 years old.

[5]Prior studies often measure stock holdings as a share of financial wealth because they rely on brokerage-account data. In contrast, we scale stock holdings by total taxable household wealth, leveraging our comprehensive data on deposits, securities, real estate, and other taxable assets. This measure captures stock exposure relative to the household's broader balance sheet.

active adjustment from passive valuation change. Active adjustment increases by 4.65% on average, with the increase concentrated in the first two post-reform years. Thus, the increase in stock exposure reflects deliberate portfolio adjustment rather than only passive valuation change.

The event-study estimates show no evidence of differential pre-trends between the treated and control groups, lending support to the parallel-trends assumption. We perform two additional identification tests. First, applying the pre-trend test proposed by Roth (2022), we show that the estimated effects are large relative to the bias that could arise from linear pre-trends with specified statistical power. Second, we form a matched sample of private sector households that closely resemble retired civil servants in their pre-reform characteristics, especially total wealth and the stock-to-wealth ratio. The matched sample yields consistent results.

We also consider several alternative explanations, including time constraints, regulatory restrictions, financial literacy, aggregate stock market conditions, and withdrawals from preferential deposits. None appears to explain the timing and magnitude of our results.[6]

The observed response is not consistent with the standard Merton framework and its habit-persistence extension, both of which predict that a reduction in permanent income lowers the optimal risky share (Merton, 1971; Brunnermeier and Nagel, 2008; Calvet and Sodini, 2014). Instead, it is consistent with a "break-even motive" under reference-dependent utility: preserving low-risk savings realizes a loss relative to pre-reform consumption, whereas investing in stocks offers a chance to narrow that loss (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992; Page et al., 2014; Lian et al., 2018; Gomes et al., 2025).[7] We illustrate

[6] Civil servants were eligible for preferential deposits with an 18% annual interest rate up to a cap based on the income replacement ratio formulas; interest income from such accounts constitutes part of their annuities. Although the preferential interest rate was reduced to 9% in July 2018 to 2020 and expired in 2021, retired civil servants had an incentive to retain these deposits until 2021 rather than move them to stocks because this return remained higher than expected stock returns after risk adjustment. We further show that the timing and magnitude of preferential deposit withdrawals do not align with the increases in retired civil servants' stock holdings.

[7] We use the term break-even motive to describe taking risk for a chance to eliminate a shortfall relative to a reference point. This mechanism is closely related to the broader notion of risk-seeking in the loss domain under prospect theory, but more specifically describes the mechanism considered here. We also acknowledge

this motive in a simple reference-dependent portfolio choice model adapted from Lian et al. (2018). Under a binary payoff, a retiree buys enough stock to restore reference consumption in the favorable state unless portfolio-reallocation capacity binds. The model takes the pre-reform reference point as given and imposes a reduced-form constraint on portfolio reallocation that preserves resources for emergency needs. The model predicts heterogeneous treatment effects based on households' pre-reform financial resources, consistent with our finding that the difference-in-differences estimates are generally larger among households with greater pre-reform wealth and deposits.

We also consider other dimensions of household financial behavior. Relative to private sector retirees, civil servant retirees' probability of stock market participation rises by 0.588 percentage points, while their deposit-to-wealth ratio and total wealth decline by 24.7% and 3.75%, respectively. We find no statistically significant change in real estate holdings. These results indicate that affected households reallocate liquid financial wealth toward stocks while experiencing a broader deterioration in their balance sheets.

We then test another prediction of the break-even motive model on stock selection. Retired civil servants tilt their portfolios toward stocks with higher total risk premiums, measured as prior realized stock returns net of the risk-free rate. This pattern is consistent with extrapolative beliefs, under which households view stocks with stronger past performance as offering greater potential to narrow the shortfall.

Finally, we present additional evidence on heterogeneity and trading behavior. The point estimates are larger among households with more dependent children, suggesting that family structure may be a source of heterogeneous responses. We also find that retired civil servants' stock sales were concentrated in positions with gains, consistent with a stronger disposition effect.

Related Literature. Our paper contributes to several strands of the finance and economics literature. First, it adds to the analysis of pension reforms and retirement savings.

the "reaching for yield" incentive as an alternative explanation (Choi and Kronlund, 2018; Chen and Choi, 2024).

Whereas prior research in this area focuses mainly on saving or contribution rates (Feldstein, 1974; Attanasio and Brugiavini, 2003; Choi, 2015; Zhang and Sialm, 2025) and incentives for later retirement (Fisher and Keuschnigg, 2008), we study the effect on risky asset allocation, which has important implications for financial markets as populations age.[8]

Because the reform we study retroactively reduced the existing annuities of a clearly defined group of retirees, it provides unusually sharp treatment assignment relative to national pension reforms that generated heterogeneous changes in pension wealth across cohorts and occupational groups (Attanasio and Brugiavini, 2003; Attanasio and Rohwedder, 2003). Moreover, our administrative data provide population-level coverage, whereas most prior studies rely on surveys or selected samples.[9]

Second, this paper is related to a core research question in household finance: the relation between lifetime resources and risky asset holdings (e.g., Campbell, 2006; Curcuru et al., 2010; Gomes, 2020). In our setting, the response to a negative permanent income shock cannot be explained by the standard positive relation between permanent income and risky asset demand. Instead, it is consistent with a break-even motive under reference-dependent utility (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992). Our population-level results also complement prior experimental evidence, for which stakes, sample size, and selection may limit external validity (Abdellaoui et al., 2008; Harbaugh et al., 2009; Page et al., 2014; Lian et al., 2018).[10]

Finally, most prior population-level analyses of comprehensive asset allocation use Scandinavian data, including Finnish data in Grinblatt (2000) and Grinblatt and Keloharju (2001)

[8]Retirees' wealth allocation decisions and their policy consequences have been important research topics (Beshears et al., 2011; Poterba et al., 2011; Scharfstein, 2018; Gomes and Smirnova, 2021; Smirnova, 2024). More broadly, formal pensions and informal transfer institutions can reshape old-age support, kinship practices, intergenerational transfers, and investments in children (Bau, 2021; Bau et al., 2026).

[9]Even the largest survey samples have only 12,734 Canadian families in King and Dicks-Mireaux (1982), 32,212 Italian families in Attanasio and Brugiavini (2003), 22,000 families in Addoum (2017), and 18,469 individuals in Neelakantan and Chang (2010).

[10]Experiments often involve small stakes compared with real-life settings, and selection into experimental samples may raise concerns about external validity. In addition, inducing a substantial wealth loss in an experimental setting is difficult (Levitt and List, 2007; Harrison and Rutstrom, 2008; Wakker, 2010; Page et al., 2014).

and Swedish data in Calvet et al. (2007), Massa and Simonov (2006), and Calvet and Sodini (2014). We extend this evidence to Taiwan, where households have high saving and residential property ownership rates, and strong family support. The contrast between our findings and those of Zhang (2021), which studies U.S. state-level pension deficits, underscores the importance of institutional and social context in household portfolio choice (e.g., Osili and Paulson, 2008; Haliassos et al., 2017).

2 Institutional Background

In Taiwan, civil servants include government employees, military personnel, and public-school educators, but not employees of state-owned enterprises or government-sponsored institutions. Prior to the 2017 reform, the pension system for civil servants in Taiwan was known for its generous benefits and early retirement ages. Operating as a defined-benefit (DB) system, the calculation of a civil servant's pension involved two components.[11] First, the monthly pension and income replacement ratio were determined based on the duration of service. Second, civil servants were allowed to save a capped amount in a preferential deposit account that offered an 18% annual interest rate. We provide further details of the pension plan in Appendix A1. In general, civil servants were assured an income replacement ratio (i.e., the ratio of annuity and preferential interest income to pre-retirement income) between 75% and 95% (as shown in the first two rows of Table 1). These generous public-sector pension benefits, however, imposed a substantial fiscal burden on the government: in 2016, the pension fund paid NT$78.6 billion (approximately US$2.62 billion) in retirement benefits to government employees, military personnel, and public-school educators.

The reform process began with the establishment of a special committee on June 8, 2016. Within 13 months, the "Civil Servants Retirement, Severance, and Dismissal Compensation Act" was passed by the Legislative Yuan, Taiwan's legislature, on June 27, 2017. The Act formed part of a broader public-sector pension reform aimed at reducing the fiscal

[11] The Public Officials Retirement Act.

burden imposed by the pension systems for government employees, military personnel, and public-school educators. For civil servants, it made five major changes: (1) the normal retirement age was raised; (2) the pension calculation formula was adjusted;[12] (3) the 18% preferential interest rate, which formed part of retired civil servants' pension income, was reduced to 9% in July 2018 to 2020 and eventually eliminated in 2021; (4) retired civil servants' reappointment was restricted; and (5) pension funding sources were adjusted. We provide more details in Appendix A2. Table 1 summarizes the income replacement ratios before and after the reform by years of service. The income replacement ratio was first cut by 12.5 to 30 percentage points in July 2018, depending on tenure and the applicable pre-reform scheme; the ratio was then scheduled to decline by 1.5 percentage points per year from 2020 to 2029.[13] In 2029, the income replacement ratio will fall to the 30%–62.5% range (as shown in the bottom row of Table 1). Relative to the pre-reform schemes, this represents a reduction of 27.5 to 45 percentage points, with shorter-tenure civil servants experiencing larger cuts.

Although the pension cut itself could have been anticipated, its magnitude was unexpectedly large. To illustrate the magnitude of the shock, consider a middle-ranked civil servant who retired with 35 years of service. Prior to the reform, this individual received approximately NT$681,000 (US$22,700) in annual pension benefits and NT$81,000 (US$2,700) in preferential interest payments, for a combined annual income of about NT$762,000 (US$25,400). Beginning in July 2018, the annual annuity was reduced to roughly NT$633,000 (US$21,100) and is scheduled to decline further to approximately NT$510,000 (US$17,000) by 2029. The reform also reduced the government's financial burden. For instance, the annual payout to

[12]The actual reduction may be greater because these calculations do not account for the transition from final base salary to the average base salary over the last fifteen years of employment. Prior to the reform, the income replacement ratio was based on salary before retirement. After the reform, the calculation base gradually transitioned to the average base salary over the last fifteen years of employment. If a civil servant received a promotion during that period, the average base salary would be lower than the final base salary used before the reform. The resulting reduction in the annuity would therefore exceed the range of 27.5 to 45 percentage points.

[13]There is an exception intended to guarantee a minimum standard of living: individuals whose monthly pension would fall below NT$33,140 (approximately US$1,105) after the reform receive a minimum of NT$33,140 (approximately US$1,105).

retired civil servants in 2020 was NT$13.5 billion (approximately US$450 million) lower than it would have been without the reform.[14] The reform is expected to reduce the government's obligations by NT$1.42 trillion (approximately US$47.3 billion) over the next 50 years.

3 Data and Summary Statistics

3.1 Data sources

Our main data source consists of tax record databases collected by the Fiscal Information Agency (FIA) of the Ministry of Finance, Taiwan. These include (1) the Nationwide Personal Property database, which contains information on deposits, bonds, stocks, housing, land, and car ownership used for property tax collection from 2003 to 2021, and (2) the Personal Income Tax database, which contains all taxable salaries, professional-practice income, bonuses, dividends, bank deposit interest, bond interest, and other personal income reported in annual tax filings from 2001 to 2021. All these datasets can be merged through unique anonymized ID numbers. The Nationwide Personal Property database provides *security-level* information, enabling us to identify which stocks each individual holds. Two key features of the Personal Income Tax database are noteworthy. First, employers report income filings, which enables us to extract employer-employee linkages and identify civil servants. Second, a detailed item on mortgage interest is recorded for tax deduction purposes, which allows us to estimate households' outstanding mortgage balances.

Our second data source consists of household registration data collected by the Ministry of Interior, which includes essential demographic information such as a unique anonymized ID for each person, the anonymized IDs of spouses and children, gender, birth date, death date, and marital status. These data allow us to form household relationships and merge them with tax record data, thereby enabling us to investigate many detailed family characteristics that are related to households' income sources, asset allocation choices, and financial pressure.

[14] Data source: Ministry of Civil Service.

We also collect the aggregate amount of outstanding mortgages and mortgage interest in Taiwan, which is published annually by the Joint Credit Information Center (JCIC). The JCIC is a nonprofit organization whose main objective is to safeguard the security and stability of the financial system. It collects, processes, and maintains the credit information of individuals and businesses, providing data for credit risk assessment and lending decisions.

We combine the JCIC's aggregate annual mortgage data with individual household deductions for mortgage interest to estimate the total outstanding mortgages for households. Following the approach adopted by Lien et al. (2021) to estimate mortgages using tax records in Taiwan, which is essentially the capitalization method proposed by Saez and Zucman (2016), we distribute the aggregate mortgage amount proportionally to each household based on its share of the household mortgage interest within the aggregate mortgage interest. We then calculate each household's real estate wealth as the assessed value of the building and land (which are separately taxed) minus the outstanding mortgage.

Lastly, we collect stock prices and returns from the Taiwan Economic Journal (TEJ) financial database. The TEJ database provides comprehensive stock information, including stock prices, outstanding shares, trading volumes, and returns. By merging the TEJ database with security-level household stock holdings data using anonymized stock IDs, we construct detailed household-level information on stock holdings, portfolio returns, and realized gains and losses.

3.2 Sample formation and summary statistics

Given our focus on pension reform, we restrict our sample to single-earner families whose primary income earner retired between 2011 and 2016 for the following two reasons. First, these individuals retired before the pension reform, so their retirement timing was unlikely affected by the reform. Because the reform was retroactively applied to former civil servants who had already retired, it permanently reduced these retirees' annuities and permanent income. Second, focusing on single-earner families helps us rule out confounding factors such

as a spouse's income status and retirement decision (Cullen and Gruber, 2000).[15] Single-earner families account for about 75% of households with individuals who retired during 2011–2016. Hence, our sample covers the majority of the relevant retiree population. Since most breadwinners in single-earner families in Taiwan are husbands, we further narrow our sample to include only families with husbands between 55 and 70 years old. This filter also ensures that our sample consists primarily of civil servants who retired with annuities. Among the 8,868 civil servants aged 55 or older who retired in 2016, only 163 (1.8%) opted to receive their pension as a lump sum.

We define an individual as retired in year t if he or she satisfies one of two criteria: (i) the individual receives pension income reported in the tax records in year t; or (ii) the individual is older than age 50, has been employed by the same employer for more than five years, and receives no payment from that employer in year t.[16] The indicator Civil Servant$_i$ equals one if the breadwinner of household i received annual labor income exceeding NT$360,000 (US$12,000; approximately the minimum annual salary) from public institutions for more than seven years and zero otherwise.[17] Based on this classification, we divide retiree households into two groups: those whose breadwinner retired as a civil servant (treatment group) and those whose breadwinner retired from the private sector (control group).

Our comprehensive panel dataset contains asset allocation, income, and household characteristics from 2013 to 2021. Detailed definitions are provided in Appendix A3. The demographic variables include husband age, wife age, an indicator for male breadwinner, and the

[15] If we consider a dual-earner household retired when one spouse retires, spousal labor supply could introduce potential confounding factors, such as delaying retirement. Conversely, if we define a dual-earner household as retired only when both partners retire, we might obtain a highly selected sample. In addition, the evidence suggests that leisure complementarity plays a significant role when two partners retire close to each other (Stancanelli and van Soest, 2012; Michaud et al., 2020).

[16] The second criterion allows us to identify civil servant retirees whose tax-exempt pension income is not observed.

[17] Our administrative data begin in 2001, after many retirees in our sample entered civil service. We therefore cannot reconstruct their completed civil-service tenure and the corresponding individual intensity of the statutory pension cut, which prevents us from conducting subgroup analyses by treatment intensity. In addition, civil-service pension income is exempt from income taxation and therefore is not reported in the tax records. Consequently, we cannot observe whether a retiree's pension is constrained by the statutory minimum-pension floor and cannot conduct a subgroup analysis based on that floor.

number of dependent children. The indicator Male Breadwinner equals one if the primary income earner is the husband and zero otherwise. The number of dependent children is the number of children below 24 years old in the household.

The household asset variables include deposits, bonds, stock holdings, the present value of cars, the assessed value of real estate net of outstanding mortgages, mortgages, and total wealth. Stock market participation is measured by $\text{SMP}_{it} = \mathbb{1}\{\text{Stock Holdings}_{it} > 0\}$, which equals one if household i holds stocks in year t and zero otherwise. Real estate ownership is defined as $\mathbb{1}\{\text{Real Estate}_{it} > 0\}$ analogously. We also construct the deposit-to-wealth ratio and stock-to-wealth ratio.[18]

The third set of variables is related to stock portfolio returns and trading outcomes. The total risk premium is the value-weighted average of stock-level returns in the prior year net of the risk-free rate. It is a realized historical measure, not a structural estimate of objective expected returns. Realized gains and realized losses are the monetary values of gains and losses realized through year-over-year changes in stock holdings and corresponding stock prices. Paper gains and paper losses are unrealized gains and losses. The proportion of gains (losses) realized is the ratio of realized gains (losses) to the sum of realized gains (losses) and paper gains (losses).

Table 2 reports means and standard deviations for the full retiree sample before the pension reform and separately for civil servant retirees and private sector retirees. Appendix Table A2 reports the corresponding sample sizes, means, standard deviations, and distributional percentiles in three panels: the full retiree sample, the civil servant retiree sample, and the private sector retiree sample. The characteristics of the civil servant and private sector groups are statistically different, which is common in population-level data given the large number of observations. We use the full sample in our main analyses for completeness and transparency; in a later robustness check, we also construct a matched sample in which

[18] In general, we capitalize deposits using the average deposit interest rate in Taiwan. Because civil servants could save in preferential deposit accounts with an 18% interest rate, we capitalize their maximum interest income using the preferential interest rate to avoid overstating deposits.

treated and control households are more homogeneous in nearly all pre-reform outcome variables.

Retired civil servants tend to hold more deposits but fewer risky assets than retirees from the private sector. The former's average deposit-to-wealth ratio is 23.8%, compared with 17.1% among private sector retirees. On the other hand, retired civil servants' average stock-to-wealth ratio is 7.9%, compared with 12.1% among private sector retirees. Nevertheless, 71.3% of retired civil servants held stocks before the reform, compared with 67.3% of private sector retirees. Bond holdings are negligible in both groups, as household bond market participation in Taiwan is largely concentrated at the top of the wealth distribution.

4 Identification Design and Main Results

4.1 Identification design

We estimate the following difference-in-differences regression to examine how households with retired civil servants adjust their asset allocation in response to the pension reform relative to those with private sector retirees:

$$\text{Asset Allocation}_{it} = b\,\text{Civil Servant}_i \times \text{Post}_t + \mathbf{B}'_{i,2016}\Lambda_t + \mathbf{X}'_{it}\Gamma + \mu_i + \delta_t + \varepsilon_{it}, \qquad (1)$$

in which $\text{Asset Allocation}_{it}$ denotes the household outcome under consideration in year t. The indicator Civil Servant_i equals one if the household breadwinner was a civil servant before retirement and zero otherwise. The post-reform indicator Post_t equals one from 2017 onward and zero otherwise. Our primary interest is b, which captures whether treated households change the outcome more than control households after the pension reform. Our principal outcomes are the stock-to-wealth ratio in log, total stock holdings in log, and active adjustment in log.

The vector $\mathbf{B}_{i,2016}$ contains financial controls measured in 2016 (so they are not affected

by the reform): the logarithm of one plus total wealth, the logarithm of one plus deposits, active adjustment $A_{i,2016}$, which measures active changes in stock exposure, passive valuation change $P_{i,2016}$, which measures changes in stock exposure attributable to price movements,[19] and the portfolio's total risk premium. Each financial control is interacted with year indicators through Λ_t. The financial-control interactions provide a linear adjustment under the conditional parallel-trends assumption, allowing households with different pre-reform portfolios and resources to follow different subsequent paths without conditioning on outcomes that may themselves respond to the reform (Sant'Anna and Zhao, 2020; Callaway and Sant'Anna, 2021; Zeldow and Hatfield, 2021).[20]

$\mathbf{X}_{it}$ contains the time-varying controls: the number of dependent children, the logarithm of one plus outstanding mortgages, and fixed effects for the husband's age. We include these time-varying variables because they are fixed burden for households and cannot be (easily) adjusted post-event.

Finally, μ_i and δ_t denote household and year fixed effects, respectively. The household fixed effects absorb time-invariant family characteristics, while year fixed effects absorb aggregate conditions common to all households. ε_{it} is the estimation error. Standard errors are clustered at the household level.

4.2 Stock exposure

Columns (1)–(3) of Tables 3 and 4 report estimates of Equation (1) using the stock-to-wealth ratio in log and stock holdings in log as dependent variables. We focus on households that held stocks before the pension refor; thus, these outcomes reflect the intensive margin of stock market participation (Addoum, 2017; Zhang, 2021).[21]

[19] Following the construction in Section 4.3, active adjustment is $A_{i,2016} = w_{i,2016} - w^p_{i,2016}$, and passive valuation change is $P_{i,2016} = w^p_{i,2016} - w_{i,2015}$. The no-trade ratio $w^p_{i,2016}$ is constructed using changes in stock closing prices between the 2015 and 2016 annual observation dates.

[20] Related empirical specifications that allow baseline characteristics to have flexible period-specific effects appear in Duflo (2001), Dustmann et al. (2022), Djourelova et al. (2025), Martin (2025), and Rao and Risch (2026).

[21] The extensive margin is analyzed in Section 5.5. Bonds are much less prevalent among Taiwanese households, as shown in Table 2.

Column (1) includes the interaction Civil Servant$_i \times$ Post$_t$ together with household and year fixed effects. Column (2) further includes the time-varying controls, and Column (3), our preferred specification, further includes the financial controls interacted with year indicators. In Table 3, the estimated coefficients across these specifications are 0.119, 0.115, and 0.110, respectively. Thus, in the preferred specification, retired civil servants increased their stock-to-wealth ratios by approximately 11.0% relative to other retirees after the pension reform.

Table 4 follows the same specification sequence. The estimated coefficients are 0.0718, 0.0755, and 0.0654 in Columns (1) to (3). The preferred estimate implies that retired civil servants increased their stock holdings by approximately 6.54%. Given average conditional stock holdings of NT$1.728 million (US$57,600) among treated households before the reform, this estimate corresponds to approximately NT$113,000 (US$3,767) in additional stock holdings. The estimates are of similar magnitude across specifications, indicating that the baseline result is not driven by observed financial burdens, household life cycles, or differential trends associated with baseline portfolios and wealth.

4.3 Active adjustment and passive valuation

The increase in stock holdings can reflect both active adjustment and passive valuation change from fluctuations in stock prices. To separate these channels, we construct a no-trade counterfactual following Calvet et al. (2009). Let $S_{i,s,t}$ denote the value of stock s held by household i at the annual observation date in year t, and let $S_{i,t} = \sum_s S_{i,s,t}$ denote household i's total stock holdings. The stock-level portfolio weight is $w_{i,s,t} = S_{i,s,t}/S_{i,t}$.

Let $Q_{s,t}$ denote the closing price used to value stock s in year t. We construct the no-trade stock valuation factor, $v^p_{i,t+1}$, from the change in closing prices between two adjacent annual observation dates:

$$v^p_{i,t+1} = \sum_s w_{i,s,t} \frac{Q_{s,t+1}}{Q_{s,t}}. \tag{2}$$

Let $w_{i,t}$ denote the observed stock-to-wealth ratio of household i in year t, $D_{i,t}$ denote

deposits, and $X_{i,t}$ denote other household wealth. Assuming that the household does not trade and that other household wealth remains constant, the passive stock-to-wealth ratio at $t+1$, $w^p_{i,t+1}$, is:

$$w^p_{i,t+1} = \frac{S_{i,t} v^p_{i,t+1}}{S_{i,t} v^p_{i,t+1} + D_{i,t}(1 + r_{f,t+1}) + X_{i,t}}. \tag{3}$$

We define active adjustment for household i in year $t+1$ as $A_{i,t+1} = w_{i,t+1} - w^p_{i,t+1}$ and passive valuation as $P_{i,t+1} = w^p_{i,t+1} - w_{i,t}$. Therefore,

$$w_{i,t+1} - w_{i,t} = \left(w_{i,t+1} - w^p_{i,t+1}\right) + \left(w^p_{i,t+1} - w_{i,t}\right) = A_{i,t+1} + P_{i,t+1}. \tag{4}$$

In our empirical analyses, we use the log specifications of active adjustment ($a_{i,t+1}$) and passive valuation ($p_{i,t+1}$), defined as follows:

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

The total log change in the stock-to-wealth ratio can therefore be decomposed as $\ln w_{i,t+1} - \ln w_{i,t} = a_{i,t+1} + p_{i,t+1}$. $a_{i,t+1}$ approximates the percentage difference between the household's observed stock exposure and the exposure generated solely by passive valuation change of its stock portfolio.

We use $a_{i,t}$ as the dependent variable and report the results in Table 5. In the preferred specification, Column (3), the coefficient on Civil Servant$_i \times$ Post$_t$ is 0.0465, implying an increase of approximately 4.65% in the observed stock-to-wealth ratio relative to the no-trade counterfactual, compared with control households. Panel (c) of Figure 1 shows that the increase in active adjustment is concentrated in the first two years in which the pension cuts were implemented. The increase in stock exposure therefore is not driven solely by price fluctuations of existing stock portfolios.

4.4 Additional identification tests

4.4.1 Parallel trends assumption and dynamic effects

The causal interpretation of our difference-in-differences analysis requires the parallel trends assumption: in the absence of the pension reform, retired civil servants and their private sector counterparts would have exhibited similar trends in their asset allocation. Although the assumption is not directly testable, we may examine their changes across time by interacting the post-reform indicator with event-time indicators as follows:

$$\text{Asset Allocation}_{it} = \sum_{\substack{j=-4 \\ j\neq -1}}^{4} b_j \, \text{Civil Servant}_i \times \mathbb{1}\{t-2017=j\} + \mathbf{B}'_{i,2016}\Lambda_t + \mathbf{X}'_{it}\Gamma + \mu_i + \delta_t + \varepsilon_{it}, \tag{5}$$

in which the event-time indicator $\mathbb{1}\{t-2017=j\}$ equals one when an observation is j years from 2017 and zero otherwise. We omit $j=-1$, corresponding to 2016, so each b_j measures the treated-control difference relative to that base year. Columns (4) and (5) of Tables 3, 4, and 5 report the event-study estimates without and with the financial-control interactions, respectively. Figure 1 plots the fully controlled estimates from Column (5): Panel (a) is for the stock-to-wealth ratio, Panel (b) is for stock holdings, and Panel (c) is for active adjustment.

The pre-reform difference-in-differences estimates are generally small and close to zero. One estimate for stock holdings is marginally significant at the 10% level, but there is no systematic pattern of differential pre-trends across the three outcomes. These estimates therefore support the parallel trends assumption underlying our difference-in-differences design.

The post-reform time path reveals two distinct stages of adjustment. In 2017 ($j=0$), after the reform was enacted but before the pension cuts began in July 2018, the stock-to-wealth ratio and stock holdings increased by 2.23% and 2.89%, respectively. Active adjustment, however, was -0.0293 in 2017. Active adjustment began when the cuts were imple-

mented: in 2018, the stock-to-wealth ratio increased by 7.57%, stock holdings increased by 6.83%, and active adjustment increased by 9.76%. In 2019, these estimates rose to 14.4%, 8.00%, and 16.7%, respectively.

The level effects persisted after this initial reallocation. In 2020, the estimates for the stock-to-wealth ratio and stock holdings are 16.9% and 8.05%, respectively, while active adjustment returns close to zero. Because active adjustment measures an annual portfolio change, this pattern indicates that households largely maintained their earlier reallocation rather than reversing it. By 2021, the estimates reaches 15.6% for the stock-to-wealth ratio and 13.8% for stock holdings, both larger than the average difference-in-differences estimates. The latter corresponds to approximately NT$238,000 (US$7,933) in additional stock holdings for the average treated stockholder. Active adjustment in 2021 is a more modest 3.13%. Taken together, the timing of reallocation indicates a modest increase in measured stock exposure in 2017, followed by concentrated active adjustment when the pension cuts took effect.

4.4.2 Pretrend test and matched sample

We acknowledge the potential power limitation of conventional pre-trend tests and therefore conduct the robustness test proposed by Roth (2022). Figure 2 presents tests for linear violations of parallel trends calibrated to 50% power in the left column and 80% power in the right column. Panels (a) and (b) report results for the stock-to-wealth ratio, Panels (c) and (d) for stock holdings, and Panels (e) and (f) for active adjustment. The hypothesized pre-trends and their implied post-reform biases differ markedly from the estimated event-study paths. The results therefore indicate that our findings are unlikely to be explained by an undetected linear pre-trend of economically meaningful magnitude.

As a second identification check, we construct a matched control group based on pre-reform observable characteristics. The matching procedure, covariate balance, and results are reported in Appendix C4. The matched-sample estimates are consistent with the baseline

results.

4.5 Alternative explanations

In this section, we consider alternative explanations for our baseline results, including pre-existing differences in the ability or willingness to invest in stocks, aggregate stock market conditions, and withdrawals from preferential deposits.

The first set of explanations concerns time constraints, financial literacy, and regulatory restrictions. For example, civil servants may have had little time to analyze and invest in stocks before retirement. They may also have been prohibited from or discouraged from investing in certain stocks because of conflicts of interest.[22] Moreover, they may have regarded their pension plan as a secure source of permanent income. Together, these factors could have limited their investment experience and financial literacy, leading to underinvestment in stocks before retirement (Guiso et al., 2002; Calvet et al., 2007). However, all these conditions existed before the reform and therefore cannot explain the immediate post-reform change in retirees' stock holdings. Furthermore, 71.3% of retired civil servants held stocks before the reform, compared with 67.3% of private sector retirees, as shown in Table 2. Our sample includes only retirees who retired before the pension reform; thus, if retirement alone induced greater stock investment, the adjustment should have occurred before the event.

The second potential explanation is that retired civil servants may have responded differently when the aggregate equity market rose. The returns on the TAIEX index were 12%, 8%, -10%, 11%, 15%, and -9% from 2013 to 2018. However, retired civil servants' stock holdings increased the most in 2017 and 2018, as shown in Figure 1, well before the substantial market increases in 2019–2021 (above 20% per year). Retired civil servants' expectations of aggregate market conditions therefore do not account for the timing of the response.

The third alternative explanation is that the phaseout of preferential deposits induced

[22] Civil servants were restricted from holding stocks related to businesses supervised by their employment agency. See the Civil Servants Service Act.

retired civil servants to transfer funds from these accounts to stocks. The preferential interest rate kept in 18% to July 2018, reduced to 9% from July 2018, and discontinued in January 2021. We address this issue in two ways. First, the 18% or 9% rate (which was almost risk-free) was more attractive than the average stock market return of 7% in the pre-event period. Retired civil servants' stock holdings and stock-to-wealth ratios began to increase in 2017 and continued to rise while the 9% rate remained available through 2020 (Figure 1). This timing misalignment suggests that the increase in stock holdings is unlikely to be driven solely by a mechanical substitution away from preferential deposits.

In addition, we conduct an event-study analysis to examine how the evolution of preferential deposits varies over time and contrast their dynamics with the observed increase in stock holdings. Specifically, we estimate the level of preferential deposits using the preferential interest rate and interest income.[23] We then estimate the following Equation (6) using the subsample of civil servants:

$$\text{Preferential Deposits}_{it} = \sum_{\tau \neq 2016} b_\tau \mathbb{1}\{t = \tau\} + \mathbf{B}'_{i,2016}\Lambda_t + \mathbf{X}'_{it}\Gamma + \mu_i + \varepsilon_{it}, \tag{6}$$

in which $\text{Preferential Deposits}_{it}$ denotes estimated preferential deposits and $\mathbb{1}\{t = \tau\}$ is an indicator for calendar year τ, with 2016 omitted. All other variables have been defined earlier. Table 6 reports two estimates of changes in preferential deposits and contrasts them with the implied change in stock holdings (the rightmost column) from the fully controlled event study in Column (5) of Table 4.[24] For example, in 2018, retired civil servants increased their stock holdings by $0.0683 \times \text{NT\$1,727,800} = \text{NT\$118,009}$ (approximately US\$3,934). However, their preferential deposits declined by only NT\$31,641 (approximately US\$1,055) in Column (1) and NT\$24,122 (approximately US\$804) in Column (2) in the same year. Moreover, their stock holdings began to rise in 2017, before the large withdrawals from preferential deposits.

[23] The preferential interest rate was 18% prior to July 2018, was reduced to 9% between July 2018 and December 2020, and was discontinued starting in January 2021. Accordingly, we capitalize preferential deposits using an annual rate of 18% before 2018, 13.5% for 2018, and 9% for the 2019–2020 period.

[24] For each year, the implied monetary change equals the event-study estimate multiplied by NT\$1,727,800 (approximately US\$57,593), the average pre-reform stock holdings of retired civil servants.

The misalignment in magnitude in 2017–2018 suggests that the withdrawal from preferential deposits cannot explain our main result.

5 Why Do Retired Civil Servants Hold More Stocks?

5.1 Merton-style implications

To explain the increased stock holdings of retired civil servants, we begin with a Merton-style portfolio choice benchmark with riskless nonfinancial income (Merton, 1971; Viceira, 2001), as the defined-benefit nature of the pension system allows pension benefits to be interpreted as a component of permanent income or human capital. Under complete markets and CRRA utility, the optimal share of financial wealth invested in the risky asset is:

$$\alpha = \left(1 + \frac{PV(Y)}{W}\right) \frac{\mu - r}{\gamma \sigma^2}, \tag{7}$$

in which α denotes the optimal risky share; $PV(Y) = \sum_{\tau=t}^{T} Y_\tau (1+r)^{-(\tau-t)}$ is the present value of future nonfinancial income; W denotes financial wealth; μ is the expected return on the risky asset; r is the risk-free rate; γ is the coefficient of relative risk aversion; and σ is the volatility of risky asset returns.[25] The effect of a change in permanent income on the risky share is:

$$\frac{\partial \alpha}{\partial PV(Y)} = \frac{1}{W} \frac{\mu - r}{\gamma \sigma^2} > 0. \tag{8}$$

This model therefore predicts that lower pension income reduces the optimal risky share, contrary to our findings. The prediction also holds with habits, commitments, or subsistence needs, as shown in an extended model in Appendix B1.

[25] T denotes the remaining income horizon. The infinite-horizon case is obtained by letting $T \to \infty$; the comparative static in Equation (8) is unchanged. Our empirical stock-to-wealth ratio uses total taxable wealth rather than financial wealth, so we use this benchmark for its directional prediction rather than as a structural mapping to the empirical coefficient.

5.2 Reference-dependent model

We next turn to reference-dependent utility (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992), in which the consumption level supported by the pre-reform annuity likely serves as a natural reference point because retirees had expected the stable and predictable payments to continue throughout retirement (Koszegi and Rabin, 2006, 2007, 2009). Maintaining savings in safe assets after the reform locks in a loss relative to this reference point, whereas reallocating wealth toward stocks offers a chance to recover part of the annuity shortfall. This choice reflects a break-even motive: accepting a sure loss or taking risk for a chance to narrow or eliminate it.[26] Prior work shows that past consumption and expectations shape reference points and that losses can increase risk-taking (Simonsohn and Loewenstein, 2006; Bordalo et al., 2018; DellaVigna et al., 2017; Lian et al., 2018).[27] The pension reform allows us to examine this behavior following a substantial and permanent income loss in a quasi-experimental setting.

Following Lian et al. (2018), we illustrate the break-even motive in a stylized reference-dependent portfolio choice model that abstracts from intertemporal optimization. The model takes the pre-reform reference point as given. We introduce "portfolio-reallocation capacity" to capture, in reduced form, the household's desire to preserve liquidity for emergency needs rather than deriving saving decisions dynamically. Let P_{0i} and P_i denote promised pre-reform and post-reform pension benefits ($P_i < P_{0i}$), and let D_{0i} and S_{0i} denote baseline deposits and stock holdings, respectively. Expressing all quantities in common monetary units over the model's decision period, pre-reform resources establish the reference point

[26] A similar qualitative response can arise under Friedman–Savage utility, in which households gamble to attain otherwise difficult-to-reach goals (Arkolakis et al., 2026). In our setting, however, the reform creates an actual loss relative to an established pre-reform consumption plan. Reference-dependent utility is therefore a more natural framework for the mechanism we study.

[27] Most evidence on risk-seeking in the loss domain, however, comes from experiments (Abdellaoui et al., 2008; Harbaugh et al., 2009; Barberis, 2013; Lian et al., 2018). These experiments often involve small stakes and selected samples, and inducing substantial wealth losses in an experimental setting is difficult (Levitt and List, 2007; Harrison and Rutstrom, 2008; Wakker, 2010). Page et al. (2014) provide related real-world evidence with smaller stakes and a smaller sample, while the evidence in Gomes et al. (2025) is primarily descriptive. Li et al. (2022) provide related evidence that workers reduce output more following stock-market gains when total income reaches a reference income.

$\bar{C}_i = P_{0i} + D_{0i} + S_{0i}$. Keeping the baseline portfolio after the reform yields safe consumption $C_i^S(P_i) = P_i + D_{0i} + S_{0i}$ and therefore a gap $G_i \equiv \bar{C}_i - C_i^S(P_i) = P_{0i} - P_i > 0$.

The retiree can reallocate $a_i \in [0, L_i]$ dollars from deposits to stocks. We refer to L_i as portfolio-reallocation capacity: the maximum amount the household is willing and able to move into stocks while preserving its desired liquidity buffer for emergency needs. We model this capacity as a function of deposits and total wealth:

$$L_i = \mathcal{L}(D_{0i}, W_{0i}^{\text{tot}}), \qquad 0 < L_i \leq D_{0i}, \qquad \mathcal{L}_D > 0, \quad \mathcal{L}_W > 0, \tag{9}$$

where W_{0i}^{tot} denotes baseline total wealth. Deposits directly measure liquid resources, whereas total wealth provides a broader proxy for financial capacity, although not all of its components are equally liquid. We assume that L_i increases with both deposits and total wealth. With respect to deposits, this amounts to assuming that the desired liquidity buffer rises less than one-for-one with liquid resources. This reduced-form restriction is consistent with buffer-stock saving and with theoretical, cross-sectional, and causal evidence linking wealth to risky-asset investment (Carroll, 1997; Wachter and Yogo, 2010; Calvet and Sodini, 2014; Briggs et al., 2021). Importantly, L_i is neither the household's entire deposit balance nor a literal borrowing limit, so the capacity bound can bind even when the household continues to hold deposits.

Denote the stock's excess payoff per dollar relative to deposits by X, then consumption relative to the reference point is $C_i(a_i, X; P_i) - \bar{C}_i = -G_i + a_i X$. Utility is linear around the reference point but steeper for losses:

$$u(C_i(a_i, X; P_i)) = \begin{cases} C_i(a_i, X; P_i) - \bar{C}_i, & C_i(a_i, X; P_i) \geq \bar{C}_i, \\ -\lambda\left[\bar{C}_i - C_i(a_i, X; P_i)\right], & C_i(a_i, X; P_i) < \bar{C}_i, \end{cases} \qquad \lambda > 1. \tag{10}$$

The retiree chooses a_i to maximize expected utility. Formally,

$$\max_{a_i \in [0, L_i]} U(a_i, G_i) \equiv \mathbb{E}[u(C_i(a_i, X; P_i))] \,. \tag{11}$$

Based on the following assumption, we derive two propositions for further empirical analysis.

Assumption 1 (Binary excess payoff à la Lian et al. (2018))**.** The excess payoff satisfies

$$X = \begin{cases} g > 0, & \text{with probability } p, \\ -\ell < 0, & \text{with probability } 1 - p, \end{cases}$$

and $pg > (1-p)\ell$, $pg < \lambda(1-p)\ell$, $G_i > 0$, and $L_i > 0$.

The first inequality gives the stock a positive expected excess payoff. The second makes additional exposure less attractive after the good state reaches the reference point. With all these, we can derive our first testable proposition.

Proposition 1 (Break-even reallocation)**.** *Under Assumption 1, the unique optimal reallocation is*

$$a_i^* = \min\left\{\frac{G_i}{g}, L_i\right\} = \min\left\{\frac{P_{0i} - P_i}{g}, L_i\right\}. \tag{12}$$

The optimal reallocation weakly increases with both the pension cut and portfolio-reallocation capacity. It increases strictly with the pension cut when the capacity bound does not bind and strictly with capacity when the bound binds.

Proof. See Appendix B2. □

The binary payoff makes the break-even motive transparent and offers a convenient interpretation: the retiree buys just enough stock for the good-return state to restore pre-reform reference consumption whenever the portfolio-reallocation capacity bound does not bind.

We next extend the reference-dependent model to incorporate extrapolative beliefs. Let $R_{s,t-1}$ denote stock s's realized annual return in year $t-1$, and let R^f_{t-1} denote the realized annual risk-free return. We define the stock's total risk premium as its realized excess return:

$$R^{\mathrm{PR}}_{s,t-1} \equiv R_{s,t-1} - R^f_{t-1}, \tag{13}$$

which is a realized measure instead of a structural estimate of the stock's ex ante expected return. We represent extrapolative beliefs with the following alternative binary-payoff assumption.

Assumption 2 (Extrapolative beliefs)**.** For stock s selected in year t, the household perceives the excess payoff to be

$$\widehat{X}_{s,t} = \begin{cases} \widehat{g}_{s,t} = h\big(R^{\mathrm{PR}}_{s,t-1}\big) > 0, & \text{with probability } p, \\ -\ell < 0, & \text{with probability } 1-p, \end{cases} \qquad h' > 0, \tag{14}$$

and $p\widehat{g}_{s,t} > (1-p)\ell$ and $p\widehat{g}_{s,t} < \lambda(1-p)\ell$.

We hold p and ℓ fixed to isolate extrapolation through the perceived favorable-state payoff. If stronger past performance also raises the perceived probability of the favorable state or reduces perceived downside risk, the preference for the stock is reinforced, although the optimum may then occur at the portfolio-reallocation capacity bound.

Proposition 2 (Extrapolative beliefs and stock choice)**.** *Under Assumption 2, optimized reference-dependent utility is weakly increasing in $R^{\mathrm{PR}}_{s,t-1}$. A stock with a higher total risk premium is therefore weakly preferred. For $G_i > 0$, the unconstrained investment required to reach the pre-reform reference point in the favorable state is $G_i/\widehat{g}_{s,t}$ and satisfies*

$$\frac{\partial}{\partial R^{\mathrm{PR}}_{s,t-1}} \left(\frac{G_i}{h(R^{\mathrm{PR}}_{s,t-1})} \right) = -\frac{G_i h'(R^{\mathrm{PR}}_{s,t-1})}{h(R^{\mathrm{PR}}_{s,t-1})^2} < 0. \tag{15}$$

Proof. See Appendix B3. □

The first part of Proposition 1 is supported by our baseline result that retired civil servants increased their stock investment through active adjustment. The second part, which is conditional on portfolio-reallocation capacity, is tested in the next section. Moreover, Proposition 2 predicts a tilt toward stocks with higher total risk premiums, which will be tested in Section 5.4.

5.3 Heterogeneity by financial resources

We next examine whether the response varies with pre-reform financial resources. Equation (9) assumes that portfolio-reallocation capacity L_i increases with deposits and total wealth. We therefore use their pre-reform values as observable proxies for L_i. We divide households into low, middle, and high groups using the 33.3rd and 66.7th percentiles of total wealth and deposits in the pooled 2016 analysis sample. Table 7 reports the results. Panels A and B group households by total wealth. For the stock-to-wealth ratio, the difference-in-differences estimates from the low to high groups are 0.0782, 0.0803, and 0.137, respectively; for stock holdings, they are 0.0506, 0.0603, and 0.0890. Panels C and D group households by deposits. The corresponding estimates are 0.0354, 0.0822, and 0.117 for the stock-to-wealth ratio and 0.0419, 0.0471, and 0.0639 for stock holdings.

The generally increasing pattern by total wealth or deposits is consistent with more stock investment under greater portfolio-reallocation capacity, as predicted in Proposition 1. Moreover, formal tests reject the equality between the low- and high-deposit groups for the stock-to-wealth ratio ($p = 0.007$), but not for stock holdings ($p = 0.440$). For the three wealth groups, the corresponding p-values are 0.074 and 0.208. The resource results are consistent with the capacity bound in our reference-dependent model: households with more financial resources may be able to finance larger stock purchases while preserving their desired liquidity buffers.

5.4 Stock selection

We next test Proposition 2, which concerns the stocks households select after the reform. We construct the portfolio's total risk premium as the value-weighted average of its constituent stocks' excess returns in the prior year (so there is no forward-looking bias):

$$R_{i,t}^{\mathrm{PR}} = \sum_{s} w_{i,s,t} R_{s,t-1}^{\mathrm{PR}}. \tag{16}$$

The term $w_{i,s,t}$ is the portfolio weight of stock s in household i's portfolio in year t, and $R_{s,t-1}^{\mathrm{PR}}$ is defined in Equation (13). The timing ensures that performance is measured before the portfolio in which the stock receives weight. The households' expected return from stocks is realized risk premium rather than a structural estimate of its expected return.[28]

Table 8 reports estimates of Equation (1) using the portfolio's total risk premium as the dependent variable. In the preferred specification, the coefficient on Civil Servant$_i$ $\times$ Post$_t$ is 0.581 percentage points and statistically significant. This finding suggests that treated households tilt toward stocks with stronger performance in the past. Under Assumption 2, a higher observed total risk premium raises the household's perceived favorable-state payoff and reduces the investment required to close a given gap in that state. We thus interpret the result as consistent with Proposition 2.

5.5 Stock participation, deposits, wealth, and real estate

We next examine whether the pension reform affects other dimensions of household financial behavior. Table 9 reports the preferred specification for four dependent variables: stock market participation, real estate value, the deposit-to-wealth ratio, and total wealth. Stock market participation is measured by SMP$_{it}$, which equals one if household i holds stocks in year t and zero otherwise. We estimate this outcome using a linear probability

[28] This is common in the literature. For instance, Fermand et al. (2024) document extrapolation of uncertainty from households' personal and local environments.

model because nonlinear fixed-effects estimators are subject to the incidental-parameters problem in a short panel (Neyman and Scott, 1948; Wooldridge, 2010; Arellano and Hahn, 2016).

The coefficient for stock market participation is 0.00588 and statistically significant, implying that the probability of holding stocks increases by 0.588 percentage points among treated households. The magnitude is modest relative to the intensive-margin response, which is consistent with the stock market participation puzzle (Haliassos and Bertaut, 1995; Kuhnen and Miu, 2017; Das et al., 2020). More broadly, stock market participation varies systematically over the life cycle (Gomes and Smirnova, 2021). The coefficient for real estate value is -0.00077 and statistically insignificant. This result is intuitive because (i) real estate transactions involve substantial adjustment costs and (ii) households are unlikely to liquidate property that serves residential needs in response to an income shock.

The coefficient for the deposit-to-wealth ratio is -0.247 and statistically significant. Thus, treated households reduced their deposit-to-wealth ratios by approximately 24.7%. This decline is consistent with the deposit-to-stock reallocation in Proposition 1 and provides complementary evidence for the model. The coefficient for the total wealth is -0.0375, implying a decline of approximately 3.75%. Based on average pre-reform wealth among treated households, this corresponds to roughly NT$606,000 (US$20,200). Taken together, these results indicate that the pension reform leads households to shift liquid wealth from deposits toward equities while their overall balance sheets deteriorate.

6 Additional Evidence

6.1 Heterogeneity by family structure

We examine whether retired civil servants' response varies with family structure. We group households by the number of dependent children. Table 10 divides the sample into households with no dependent children, one dependent child, and two or more dependent

children. We then present the difference-in-differences estimates for each group. Panel A reports estimates for the stock-to-wealth ratio, and the coefficients on Civil Servant$_i \times$ Post$_t$ are 0.100, 0.128, and 0.167 across the three groups. Panel B reports corresponding estimates of 0.0626, 0.0950, and 0.103 for stock holdings. The point estimates increase with the number of dependent children for both outcomes. Formal tests for coefficient difference, however, do not reject equality between households with no dependent children and those with two or more for either the stock-to-wealth ratio or stock holdings.

One possible interpretation of the family-structure pattern is that retired civil servants with more children increase stock holdings because they wish to leave larger bequests. Using a specification similar to that in Table 10, we conduct the subgroup analyses using the total number of children, including adult children. We present the estimation results in Appendix C. Unlike the dependent-child results in Table 10, the difference-in-differences estimates for households with two or more children are actually smaller than those for households without children. This contrast does not support the bequest-motive explanation.

6.2 Disposition effect

Finally, we examine whether the annuity cuts strengthened the disposition effect, a well-documented tendency of investors to sell winning stocks too early while holding on to losing stocks for too long (Shefrin and Statman, 1985; Odean, 1998; Barber et al., 2007).[29] To measure this behavior, we track households' year-over-year changes in stock holdings and corresponding stock prices. This procedure allows us to identify realized gains, realized losses, paper gains, and paper losses.[30]

Table 11 reports estimates of Equation (1). Panel A uses the logarithm of one plus realized gains as the dependent variable, while Panel B uses the logarithm of one plus realized losses. The specifications follow the same sequence as the main tables. In the

[29] Jin and Peng (2024) builds a model in which an incorrect belief that small samples represent the properties of the underlying population can lead to the disposition effect.

[30] Because we cannot observe transactions between two annual tax filings, these measures should be interpreted as reflecting transactions associated with longer-term stock holdings.

preferred specification, the coefficient on Civil Servant$_i$ $\times$ Post$_t$ is 0.0999 and statistically significant for realized gains. The corresponding coefficient for realized losses is 0.0328 and statistically insignificant. Thus, the evidence of increased realization is concentrated among positions with gains.

Following Odean (1998), we also construct the proportion of gains realized and the proportion of losses realized.[31] These supplemental results are reported in Appendix C3. The preferred estimates are 0.0058 for the proportion of gains realized and 0.0012 for the proportion of losses realized; only the former is statistically significant.

Taken together, the results show that the increase in realized selling activity is concentrated among positions with gains. This pattern is consistent with a stronger disposition effect. It is important to note that capital gains on stock investments are not taxed in Taiwan, yet dividends are subject to income taxation. Therefore, the disposition effect documented here cannot be attributed to tax-related motives such as short-term capital gains taxation, tax-loss harvesting, or tax-swap strategies. Instead, the evidence points to behavioral explanations that are related to reference-dependent preferences.

7 Conclusion

In this paper, we provide population-level evidence on how retirees' asset allocation responds to an unexpected and substantial annuity cut. We analyze the 2017 civil servant pension reform in Taiwan, which retroactively reduced retirement annuities beginning in July 2018 and scheduled further reductions through 2029. Using administrative tax records covering Taiwanese households and a difference-in-differences design, we find that treated households increased their stock-to-wealth ratios by 11.0% and their stock holdings by 6.54%. In addition, their active adjustment increased by 4.65% on average and such increase is concentrated in the first two post-reform years. In addition, their deposit-to-wealth ratio

[31] Odean (1998) defines the ratios using the number of stocks sold and held. We instead use the value of realized and paper gains or losses because investors may not fully liquidate a stock in a single transaction or year and because positions carry different portfolio weights.

and total wealth declined by 24.7% and 3.75%, respectively, while their real estate holdings did not change measurably. The point estimates are also larger among households with more dependent children.

Our additional identification tests and robustness checks support a causal interpretation of our difference-in-differences estimates. We also consider several alternative explanations, including time constraints, regulatory restrictions, financial literacy, aggregate stock market conditions, and withdrawals from preferential deposits; none can explain our results. The family-structure analysis also does not support a bequest-motive explanation.

Retired civil servants' increased stock holdings following an annuity cut cannot be explained by the Merton-style benchmark (Merton, 1971; Viceira, 2001). Instead, this response is more consistent with a break-even motive under reference-dependent utility: retirees facing a loss relative to habitual consumption take greater financial risk for a chance to narrow the shortfall (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992). Our model's predictions receive further empirical support: the difference-in-differences estimates generally increase with pre-reform wealth and deposits, and treated households tilt their portfolios toward stocks with higher risk premiums in the past. As additional evidence, treated households also exhibit a stronger disposition effect. Our evidence complements prior experimental and survey studies that may be limited by smaller stakes, smaller samples, and selection concerns.

These findings also have intergenerational distributional implications. Current retirees bear benefit reductions and greater portfolio risk, while improved solvency may help preserve benefits for future retirees who might otherwise receive less because of the system's financial unsustainability. Determining the sign of the welfare effect requires an overlapping-generations framework that incorporates current and future cohorts, demographic change, fiscal sustainability, saving, and households' behavioral responses (Cheng et al., 2020). Such analysis is important but beyond the scope of our current investigation.

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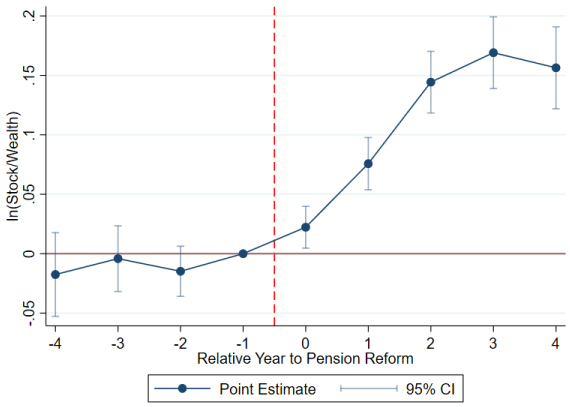
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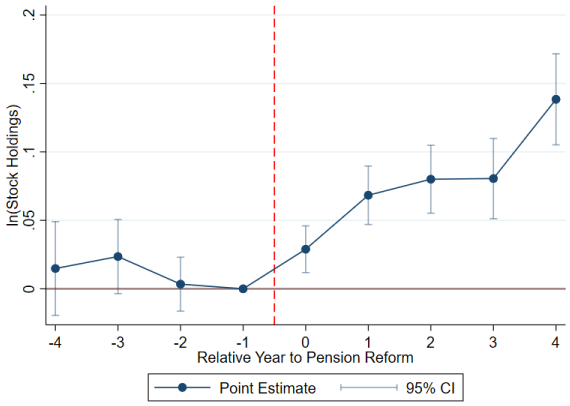
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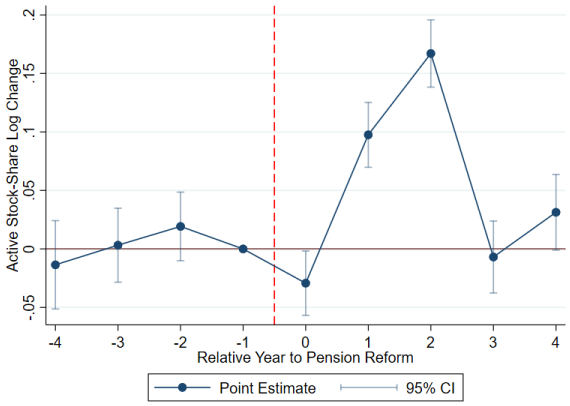
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(a) Stock-to-wealth ratio in log



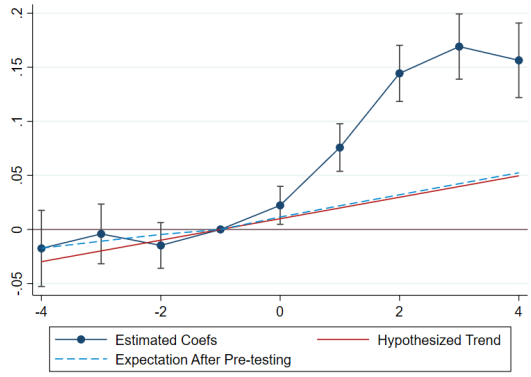
(b) Stock holdings in log



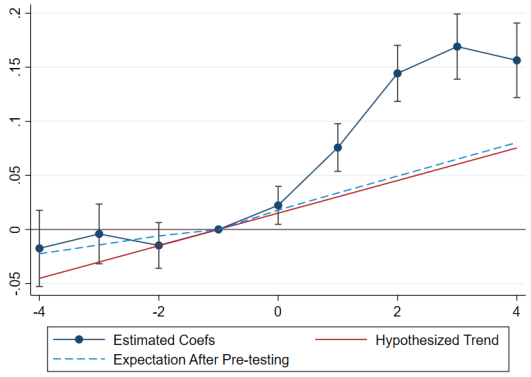
(c) Active adjustment in log

Figure 1: Event-Study Estimates for Stock Exposure and Active Adjustment

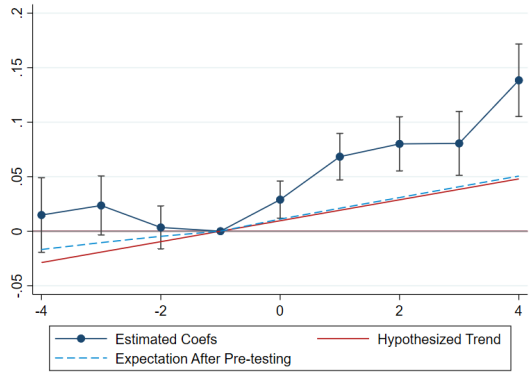
This figure presents the estimates of Equation (5) from Column (5) of Tables 3–5. Panels (a), (b), and (c) report estimates for the logarithm of the stock-to-wealth ratio, the logarithm of stock holdings, and active adjustment in the stock-to-wealth ratio, respectively. The dots represent point estimates, and the bars denote 95% confidence intervals. Relative Year 0 corresponds to 2017, when the reform legislation was passed, and Relative Year 1 corresponds to 2018, when the pension cuts began. The omitted relative year is −1.



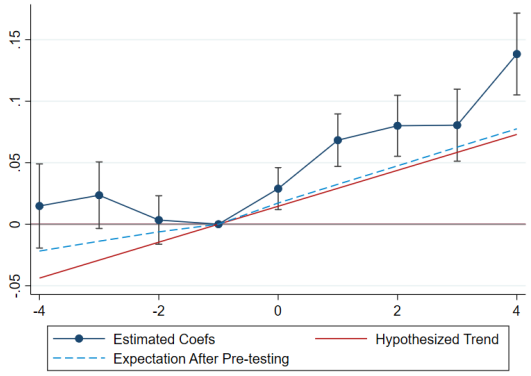
(a) Logarithm of the stock-to-wealth ratio; power: 0.5



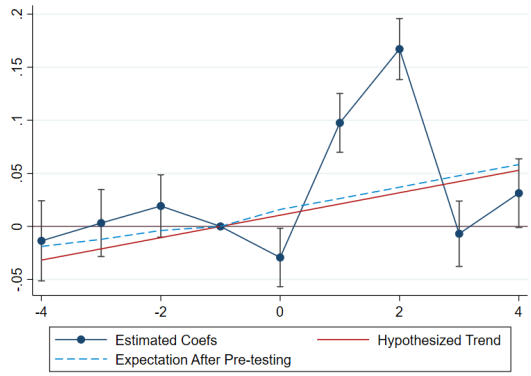
(b) Logarithm of the stock-to-wealth ratio; power: 0.8



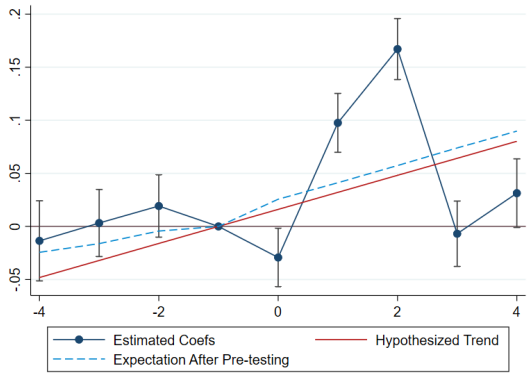
(c) Logarithm of stock holdings; power: 0.5



(d) Logarithm of stock holdings; power: 0.8



(e) Active log stock-to-wealth change; power: 0.5



(f) Active log stock-to-wealth change; power: 0.8

Figure 2: Robustness Checks for Pre-trend Testing

This figure presents the pre-trend robustness test proposed by Roth (2022). Each row corresponds to one of the three principal outcomes. The left column assumes a linear pre-trend calibrated to 50% power, and the right column assumes a linear pre-trend calibrated to 80% power. The solid blue line reports the event-study estimates, the red line denotes the hypothesized linear trend, and the dashed blue line reports the expected estimates conditional on passing the conventional pre-trend test under that trend. The omitted relative year is -1.

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%

This table reports the income replacement ratios for Taiwanese civil servants before and after the 2017 pension reform, by years of service. Before the reform, retirees were covered by pension scheme (A) or (B), whose benefit formulas are described in Appendix A1. The reform was implemented in July 2018. Income replacement ratios were reduced further by 1.5 percentage points per year from 2020 through 2029, when they reach the levels reported in the final row.

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

	Population	Civil Servant	Private Sector
Total Wealth (thousands)	16531.4	16156.7	16587.0
	(171123.0)	(25999.1)	(183109.2)
Stock Market Participation	0.678	0.713	0.673
	(0.467)	(0.452)	(0.469)
Stock-to-Wealth Ratio	0.115	0.0786	0.121
	(3.246)	(0.410)	(3.481)
Conditional Stock-to-Wealth Ratio	0.162	0.107	0.170
	(3.862)	(0.479)	(4.15)
Deposit-to-Wealth Ratio	0.180	0.238	0.171
	(0.855)	(0.919)	(0.844)
Active Log Stock-to-Wealth Change	0.387	0.296	0.401
	(1.22)	(1.071)	(1.243)
Passive Log Stock-to-Wealth Change	-0.449	-0.365	-0.462
	(1.014)	(0.778)	(1.046)
Total Risk Premium	3.750	4.041	3.704
	(27.29)	(26.62)	(27.40)
Proportion of Realized Gains	0.175	0.196	0.172
	(0.333)	(0.346)	(0.331)
Proportion of Realized Losses	0.126	0.142	0.124
	(0.294)	(0.308)	(0.292)
Realized Gains (thousands)	57.90	48.88	59.31
	(797.2)	(358.3)	(845.6)
Realized Losses (thousands)	31.01	26.30	31.75
	(521.2)	(394.4)	(538.4)
Paper Gains (thousands)	85.84	51.70	91.20
	(2967.8)	(463.9)	(3187.0)
Paper Losses (thousands)	54.03	40.71	56.12
	(1290.9)	(486.4)	(1375.1)
Deposits (thousands)	3313.4	4407.3	3151.0
	(9678.3)	(8272.9)	(9859.5)
Bonds (thousands)	2.512	0.430	2.820
	(245.1)	(34.23)	(262.3)
Stock Holdings (thousands)	2099.4	1242.1	2226.7
	(42158.2)	(5164.1)	(45133.4)
Conditional Stock Holdings (thousands)	3079.0	1727.8	3291.1
	(51072.2)	(5990.9)	(54880.5)
Present Value of Cars (thousands)	151.2	155.2	150.6
	(381.2)	(318.4)	(389.7)
Assessed Value of Real Estate (thousands)	10964.9	10351.7	11055.9
	(131799.1)	(21460.1)	(140999.4)

Table 2: Summary Statistics in the Pre-Reform Period (2013–2016) (continued)

	Population	Civil Servant	Private Sector
Real Estate Ownership	0.903	0.948	0.897
	(0.295)	(0.223)	(0.304)
Mortgage (thousands)	295.6	266.9	299.8
	(2992.0)	(1425.0)	(3159.0)
Husband Age	60.75	61.41	60.65
	(3.887)	(3.993)	(3.861)
Wife Age	57.45	58.39	57.31
	(5.055)	(4.948)	(5.056)
Male Breadwinner	0.732	0.860	0.713
	(0.443)	(0.347)	(0.452)
Number of Dependent Children	0.317	0.278	0.323
	(0.655)	(0.600)	(0.662)
Observations	434441	56147	378294

This table presents summary statistics for the full sample in the pre-reform period, civil servant households in the treatment group, and private sector households in the control group. Means are reported with standard deviations in parentheses. Monetary amounts reported in thousands are in NT$. Conditional Stock Holdings is calculated among households with positive stock holdings. Conditional Stock-to-Wealth Ratio additionally requires a nonmissing ratio; the unconditional ratio is reported separately. Active and passive log changes refer to a and p, rather than the level changes A and P. Variable-specific observation counts are reported in Appendix Table A2. All variables are defined in Table A1.

Table 3: Effect of the 2017 Pension Reform on the Logarithm of the Stock-to-Wealth Ratio

	(1)	(2)	(3)	(4)	(5)
	Logarithm of the Stock-to-Wealth Ratio				
Civil Servant×Post	0.119***	0.115***	0.110***		
	(0.0103)	(0.0103)	(0.0104)		
Civil Servant×$\mathbb{1}\{t-2017=-4\}$				0.00394	-0.0175
				(0.0176)	(0.0180)
Civil Servant×$\mathbb{1}\{t-2017=-3\}$				0.00946	-0.00414
				(0.0135)	(0.0141)
Civil Servant×$\mathbb{1}\{t-2017=-2\}$				0.000743	-0.0148
				(0.00970)	(0.0108)
Civil Servant×$\mathbb{1}\{t-2017=0\}$				0.0304***	0.0223**
				(0.00882)	(0.00896)
Civil Servant×$\mathbb{1}\{t-2017=1\}$				0.0907***	0.0757***
				(0.0110)	(0.0112)
Civil Servant×$\mathbb{1}\{t-2017=2\}$				0.164***	0.144***
				(0.0130)	(0.0132)
Civil Servant×$\mathbb{1}\{t-2017=3\}$				0.186***	0.169***
				(0.0151)	(0.0154)
Civil Servant×$\mathbb{1}\{t-2017=4\}$				0.174***	0.156***
				(0.0174)	(0.0176)
Number of Dependent Children		-0.00243	-0.00112	-0.00244	-0.00112
		(0.00633)	(0.00632)	(0.00633)	(0.00631)
$\ln(1+\text{Mortgage})$		0.0213***	0.0201***	0.0213***	0.0201***
		(0.000485)	(0.000488)	(0.000485)	(0.000488)
Household Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Husband-Age Fixed Effects	No	Yes	Yes	Yes	Yes
Financial Controls × Year FE	No	No	Yes	No	Yes
Observations	727,959	727,959	726,066	727,959	726,066
R^2	0.0161	0.0220	0.0305	0.0223	0.0308

This table examines the effect of the 2017 pension reform on the logarithm of the stock-to-wealth ratio. The sample consists of households that held stocks before the reform. Columns (1)–(3) report estimates of Equation (1). Column (1) includes household and year fixed effects. Column (2) adds the number of dependent children, the logarithm of one plus outstanding mortgages, and husband-age fixed effects. Column (3) additionally includes the financial controls interacted with year indicators. Columns (4) and (5) report the corresponding estimates of Equation (5) without and with the financial controls. The omitted relative year is -1. Standard errors are clustered at the household level and are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. All variables are defined in Table A1.

Table 4: Effect of the 2017 Pension Reform on the Logarithm of Stock Holdings

	(1)	(2)	(3)	(4)	(5)
	Logarithm of Stock Holdings				
Civil Servant×Post	0.0718***	0.0755***	0.0654***		
	(0.00997)	(0.00999)	(0.0101)		
Civil Servant×$\mathbb{1}\{t-2017=-4\}$				0.0141	0.0148
				(0.0173)	(0.0175)
Civil Servant×$\mathbb{1}\{t-2017=-3\}$				0.0244*	0.0236*
				(0.0135)	(0.0138)
Civil Servant×$\mathbb{1}\{t-2017=-2\}$				0.00574	0.00341
				(0.00962)	(0.0101)
Civil Servant×$\mathbb{1}\{t-2017=0\}$				0.0330***	0.0289***
				(0.00854)	(0.00870)
Civil Servant×$\mathbb{1}\{t-2017=1\}$				0.0761***	0.0683***
				(0.0107)	(0.0109)
Civil Servant×$\mathbb{1}\{t-2017=2\}$				0.0940***	0.0800***
				(0.0124)	(0.0127)
Civil Servant×$\mathbb{1}\{t-2017=3\}$				0.0948***	0.0805***
				(0.0146)	(0.0149)
Civil Servant×$\mathbb{1}\{t-2017=4\}$				0.158***	0.138***
				(0.0167)	(0.0170)
Number of Dependent Children		-0.0111*	-0.0118*	-0.0111*	-0.0119*
		(0.00625)	(0.00626)	(0.00625)	(0.00626)
$\ln(1+\text{Mortgage})$		-0.000484	-0.000664	-0.000512	-0.000683
		(0.000439)	(0.000444)	(0.000439)	(0.000444)
Household Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Husband-Age Fixed Effects	No	Yes	Yes	Yes	Yes
Financial Controls × Year FE	No	No	Yes	No	Yes
Observations	731,098	731,098	727,941	731,098	727,941
R^2	0.0138	0.0142	0.0186	0.0143	0.0188

This table examines the effect of the 2017 pension reform on the logarithm of stock holdings. The sample consists of households that held stocks before the reform. Columns (1)–(3) report estimates of Equation (1). Column (1) includes household and year fixed effects. Column (2) adds the number of dependent children, the logarithm of one plus outstanding mortgages, and husband-age fixed effects. Column (3) additionally includes the financial controls interacted with year indicators. Columns (4) and (5) report the corresponding estimates of Equation (5) without and with the financial controls. The omitted relative year is -1. Standard errors are clustered at the household level and are shown in parentheses. * $p<0.10$, ** $p<0.05$, and *** $p<0.01$. All variables are defined in Table A1.

Table 5: Effect of the 2017 Pension Reform on Active Adjustment

	(1)	(2)	(3)	(4)	(5)
	Active Log Stock-to-Wealth Change				
Civil Servant×Post	0.0505***	0.0568***	0.0465***		
	(0.00747)	(0.00746)	(0.00776)		
Civil Servant×$\mathbb{1}\{t-2017=-4\}$				0.00190	-0.0136
				(0.0183)	(0.0193)
Civil Servant×$\mathbb{1}\{t-2017=-3\}$				0.0331**	0.00321
				(0.0147)	(0.0161)
Civil Servant×$\mathbb{1}\{t-2017=-2\}$				0.0492***	0.0192
				(0.0133)	(0.0150)
Civil Servant×$\mathbb{1}\{t-2017=0\}$				-0.00178	-0.0293**
				(0.0126)	(0.0140)
Civil Servant×$\mathbb{1}\{t-2017=1\}$				0.128***	0.0976***
				(0.0128)	(0.0141)
Civil Servant×$\mathbb{1}\{t-2017=2\}$				0.196***	0.167***
				(0.0133)	(0.0147)
Civil Servant×$\mathbb{1}\{t-2017=3\}$				0.0125	-0.00689
				(0.0142)	(0.0157)
Civil Servant×$\mathbb{1}\{t-2017=4\}$				0.0555***	0.0313*
				(0.0157)	(0.0165)
Number of Dependent Children		-0.0191***	-0.0171***	-0.0190***	-0.0170***
		(0.00507)	(0.00505)	(0.00507)	(0.00505)
$\ln(1+\text{Mortgage})$		0.0121***	0.0111***	0.0121***	0.0110***
		(0.000469)	(0.000486)	(0.000469)	(0.000486)
Household Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Husband-Age Fixed Effects	No	Yes	Yes	Yes	Yes
Financial Controls × Year FE	No	No	Yes	No	Yes
Observations	731,098	731,098	727,941	731,098	727,941
R^2	0.00380	0.00880	0.0203	0.00926	0.0207

This table examines the effect of the 2017 pension reform on active adjustment in the logarithm of the stock-to-wealth ratio. Active adjustment is the observed log change net of passive valuation computed from closing-price changes in the baseline stock portfolio. The sample consists of households that held stocks before the reform. Columns (1)–(3) report estimates of Equation (1), and Columns (4) and (5) report estimates of Equation (5). The sequence of controls is the same as in Tables 3 and 4. The omitted relative year is −1. Standard errors are clustered at the household level and are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. All variables are defined in Table A1.

Table 6: Event Study for Withdrawals of Preferential Deposits

	(1)	(2)	(3)
	Preferential Deposits		Implied Change in Stock Holdings
$\mathbb{1}\{t = 2013\}$	18,233.2***	-29,515.3**	25,571.4
	(3,229.3)	(14,148.8)	
$\mathbb{1}\{t = 2014\}$	12,842.4***	-23,630.6**	40,776.1
	(2,237.8)	(10,691.2)	
$\mathbb{1}\{t = 2015\}$	8,409.4***	-21,536.5***	5,891.8
	(1,499.8)	(6,308.9)	
$\mathbb{1}\{t = 2017\}$	-3,798.2***	-5,200.0	49,933.4
	(1,147.4)	(4,411.9)	
$\mathbb{1}\{t = 2018\}$	-31,641.0***	-24,122.1***	118,008.7
	(1,801.0)	(6,513.8)	
$\mathbb{1}\{t = 2019\}$	-119,964.5***	-77,933.9***	138,224.0
	(4,049.9)	(13,175.5)	
$\mathbb{1}\{t = 2020\}$	-173,902.8***	-49,612.2***	139,087.9
	(3,972.5)	(12,068.6)	
Household Fixed Effects	Yes	Yes	Yes
Time-Varying Controls	Yes	Yes	Yes
Financial Controls × Year FE	No	Yes	Yes
Observations	128,888	128,350	727,941
R^2	0.08445	0.1123	—

This table compares changes in estimated preferential deposits with the implied change in stock holdings. Columns (1) and (2) estimate Equation (6) using the subsample of civil servant households. Both columns include the time-varying controls and household fixed effects; Column (2) additionally includes the financial controls interacted with year indicators. Column (3) multiplies the event-study estimates from Column (5) of Table 4 by NT$1,727,800, the average pre-reform conditional stock holdings of civil servant households. The em dash in the R^2 row indicates that Column (3) is a derived quantity rather than a separately estimated regression. Monetary amounts are in NT$, and 2016 is the omitted year. Standard errors are clustered at the household level and are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table 7: Heterogeneity by Pre-Reform Wealth and Deposits

Pre-Reform Resource Group	(1) Low	(2) Middle	(3) High
Panel A: Logarithm of the Stock-to-Wealth Ratio, by Total Wealth			
Civil Servant×Post	0.0782***	0.0803***	0.1370***
	(0.0299)	(0.0173)	(0.0137)
Observations	153,393	254,335	317,806
R^2	0.0518	0.0446	0.0472
p-value: Low = High		0.0737	
Panel B: Logarithm of Stock Holdings, by Total Wealth			
Civil Servant×Post	0.0506*	0.0603***	0.0890***
	(0.0273)	(0.0172)	(0.0136)
Observations	154,651	254,845	317,911
R^2	0.0248	0.0299	0.0244
p-value: Low = High		0.2083	
Panel C: Logarithm of the Stock-to-Wealth Ratio, by Deposits			
Civil Servant×Post	0.0354	0.0822***	0.1170***
	(0.0270)	(0.0187)	(0.0135)
Observations	246,402	177,737	301,395
R^2	0.0584	0.0483	0.0320
p-value: Low = High		0.0071	
Panel D: Logarithm of Stock Holdings, by Deposits			
Civil Servant×Post	0.0419*	0.0471**	0.0639***
	(0.0254)	(0.0188)	(0.0131)
Observations	247,511	178,317	301,574
R^2	0.0449	0.0308	0.0207
p-value: Low = High		0.4401	
Household Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Time-Varying Controls	Yes	Yes	Yes
Financial Controls × Year FE	Yes	Yes	Yes

This table examines whether the effect of the 2017 pension reform varies with households' pre-reform financial resources. Low, Middle, and High denote the bottom, middle, and top groups formed using the 33.3rd and 66.7th percentiles of the indicated resource in the pooled 2016 analysis sample. Panels A and B group households by total wealth; Panels C and D group households by deposits. Each column estimates Equation (1) for the indicated subgroup using the preferred specification, which includes household and year fixed effects, the time-varying controls, and the financial controls interacted with year indicators. The reported p-values test equality of the coefficients for the Low and High groups. Standard errors are clustered at the household level and are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table 8: Effect of the 2017 Pension Reform on Stock Selection

	(1)	(2)	(3)
	Total Risk Premium		
Civil Servant×Post	0.863***	0.882***	0.581***
	(0.199)	(0.199)	(0.179)
Household Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Time-Varying Controls	No	Yes	Yes
Financial Controls × Year FE	No	No	Yes
Observations	731,098	731,098	727,941
R^2	0.198	0.198	0.281

This table examines whether civil servant households reallocated toward stocks with higher total risk premiums following the 2017 pension reform. The dependent variable is the value-weighted average of the stocks' prior-year realized returns net of the risk-free rate. It is a historical realized measure and not a structural estimate of objective expected returns. The sample consists of households that held stocks before the reform. Column (1) includes household and year fixed effects. Column (2) adds the time-varying controls. Column (3) additionally includes the financial controls interacted with year indicators. Standard errors are clustered at the household level and are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. All variables are defined in Table A1.

Table 9: Effect of the 2017 Pension Reform on Other Financial Decisions

	(1) Stock Market Participation	(2) Logarithm of One Plus Real Estate	(3) Logarithm of the Deposit-to-Wealth Ratio	(4) Logarithm of One Plus Total Wealth
Civil Servant ×Post	0.00588***	-0.000770	-0.247***	-0.0375***
	(0.00129)	(0.0117)	(0.00723)	(0.00804)
Household Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Time-Varying Controls	Yes	Yes	Yes	Yes
Financial Controls × Year FE	Yes	Yes	Yes	Yes
Observations	1,110,056	1,100,965	604,871	1,106,355
R^2	0.00278	0.0209	0.0529	0.0360

This table examines the effect of the 2017 pension reform on other household financial outcomes. The dependent variables are Stock Market Participation in Column (1), the logarithm of one plus real estate in Column (2), the logarithm of the deposit-to-wealth ratio in Column (3), and the logarithm of one plus total wealth in Column (4). Stock Market Participation equals one if the household has positive stock holdings and zero otherwise. Each column reports the preferred specification of Equation (1), including household and year fixed effects, the time-varying controls, and the financial controls interacted with year indicators. Standard errors are clustered at the household level and are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. All variables are defined in Table A1.

Table 10: Subgroup Analysis Based on the Number of Dependent Children

	(1)	(2)	(3)
Number of Dependent Children	0	1	≥ 2
Panel A: Logarithm of the Stock-to-Wealth Ratio			
Civil Servant×Post	0.100***	0.128***	0.167***
	(0.0114)	(0.0337)	(0.0626)
Observations	602,735	86,569	36,762
R^2	0.0320	0.0336	0.0530
p-value: (1) = (3)		0.2921	
Panel B: Logarithm of Stock Holdings			
Civil Servant×Post	0.0626***	0.0950***	0.103*
	(0.0110)	(0.0338)	(0.0606)
Observations	604,322	86,775	36,844
R^2	0.0199	0.0168	0.0274
p-value: (1) = (3)		0.5120	
Household Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Time-Varying Controls	Yes	Yes	Yes
Financial Controls × Year FE	Yes	Yes	Yes

This table examines whether the effect of the 2017 pension reform varies with the number of dependent children. The sample is divided into households with no dependent children, one dependent child, and two or more dependent children. Panel A reports estimates for the logarithm of the stock-to-wealth ratio, and Panel B reports estimates for the logarithm of stock holdings. Each column estimates Equation (1) for the indicated subgroup using the preferred specification, which includes household and year fixed effects, the time-varying controls, and the financial controls interacted with year indicators. The reported p-values test equality of the treatment effects in Columns (1) and (3), comparing households with no dependent children with those with two or more. Standard errors are clustered at the household level and are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table 11: Effect of the 2017 Pension Reform on Realized Gains and Realized Losses

	(1)	(2)	(3)
Panel A: Logarithm of One Plus Realized Gains			
Civil Servant×Post	0.175***	0.216***	0.0999***
	(0.0327)	(0.0324)	(0.0326)
R^2	0.0899	0.0985	0.106
Panel B: Logarithm of One Plus Realized Losses			
Civil Servant×Post	0.0468*	0.0798***	0.0328
	(0.0278)	(0.0277)	(0.0279)
R^2	0.0464	0.0529	0.0580
Household Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Time-Varying Controls	No	Yes	Yes
Financial Controls × Year FE	No	No	Yes
Observations	731,098	731,098	727,941

This table examines the effect of the 2017 pension reform on stock-selling behavior. Panel A uses the logarithm of one plus realized gains as the dependent variable, and Panel B uses the logarithm of one plus realized losses. The sample consists of households that held stocks before the reform. Column (1) includes household and year fixed effects. Column (2) adds the time-varying controls. Column (3) additionally includes the financial controls interacted with year indicators. Standard errors are clustered at the household level and are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. All variables are defined in Table A1.

Appendix

A Institutional Details

A1 The civil servants' pension system before the reform

Salary calculation within Taiwan's civil service operates under a points-based framework in which distinct ranks and levels are assigned specific salary points. These points form the foundation for determining a civil servant's monthly income. Generally speaking, a civil servant's monthly income is composed of four primary components:
i. Base Salary: This constitutes the core salary determined by the accumulated years of service and associated salary points.
ii. Professional Allowance: Offered to civil servants with specialized skills, qualifications, or expertise relevant to their roles. It serves as additional compensation for their professional proficiency.
iii. Position Allowance: Reflects the responsibilities and hierarchical position within the civil service. Higher-ranking positions or roles with greater responsibilities may receive this additional allowance.
iv. Remote Area Allowance: Provided to those serving in remote or special areas and overseas.

The combination of these four components constitutes the comprehensive monthly income of a civil servant in Taiwan. Typically, the base salary accounts for approximately half of a civil servant's total monthly salary, thus serving as the foundational component of the compensation framework. Prior to the 2017 reform, the pension system for civil servants in Taiwan was known for its generous benefits and early retirement ages. Operating as a defined-benefit system, the calculation of a civil servant's pension involved a two-step process. First, the monthly pension and income replacement ratio were determined based on the duration of service. Second, civil servants were provided with the opportunity to save in a preferential deposit account with an 18% annual interest rate. Two distinct formulas were used to determine the income replacement ratio:

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

$$\frac{\text{Monthly Pension} + \text{Preferential Interest}}{\begin{array}{c}\text{Base Salary+Professional Allowance} \\ \text{+Position Allowance+Year-end Bonus/12}\end{array}} = 75\% + (\text{Tenure} - 15)\%. \tag{B}$$

in which individuals with tenure of less than 15 years were assigned 15 years, with tenure capped at 30 years. The base salary was determined based on the individual's final salary prior to retirement. Based on these formulas, the civil servant's pension was determined by the plan offering the lower preferential interest. Typically, Formula A was designed for higher-ranked officers, while Formula B catered to lower-ranked civil servants. Regardless of the formula employed, civil servants were guaranteed a minimum of approximately 75% of their monthly income while actively working, with the potential to receive up to 95% (as shown in the first two rows of Table 1).

A2 Pension reform in relation to civil servants in 2017

The "Civil Servants Retirement, Severance, and Dismissal Compensation Act" was passed by the Legislative Yuan, Taiwan's legislature, on June 27, 2017, following its third reading. The Act formed part of a broader policy initiative aimed at improving the financial sustainability of the pension systems for government employees, military personnel, and public-school educators. Key components affecting civil servants include the following:

- Increasing the Normal Retirement Age: The reform raised the normal retirement age for civil servants, ensuring that they retire later than in previous years.
- Adjustment of the Pension Calculation: From July 2018, the calculation of the pension was modified to reduce the generous benefits that were previously granted.
- Elimination of the 18% Preferential Interest Rate: Civil servants were previously offered an 18% preferential interest rate. This was eliminated because it contributed to the financial imbalance in the system.[32]
- Funding Mechanism: A new pension funding mechanism was introduced, transitioning from a purely pay-as-you-go system to a partially funded system.

From July 2018 onward, the pension calculation process became more straightforward. Along with the phaseout of the 18% preferential interest rate, the formula for the income replacement ratio was modified as follows:

$$\frac{\text{Monthly Pension}}{\text{Average Base Salary} \times 2} = \begin{cases} 45\% + (\text{Tenure} - 15) \times 1.5\% & \\ \quad - \min\{\max(\text{Year} - 2019, 0), 10\} \times 1.5\%, & \text{if Tenure} \leq 35, \\ 75\% + (\text{Tenure} - 35) \times 0.5\% & \\ \quad - \min\{\max(\text{Year} - 2019, 0), 10\} \times 1.5\%, & \text{if Tenure} \geq 35. \end{cases} \tag{C}$$

In the updated formula, individuals with tenure of less than 15 years were assigned 15 years, with tenure capped at 40 years. The "average base salary," initially calculated using the last five years of employment beginning in July 2018, is gradually being extended to the last fifteen years of employment by 2029. A substantial reduction in the income replacement ratio occurred in July 2018, followed by annual reductions of 1.5 percentage points from 2020 to 2029. In 2029, the income replacement ratio will range from 30% to 62.5% (as presented in the bottom row of Table 1). There is one exception: to guarantee a minimum standard of living, individuals whose monthly pension would fall below NT$33,140 (approximately US$1,105) after the reform receive a minimum of NT$33,140 (approximately US$1,105).

A3 Variable definitions

[32]The special interest rate was 18% until July 2018, was reduced to 9% between July 2018 and December 2020, and was discontinued from January 2021 onwards.

Table A1: Variable Definitions

Variable	Definition
Husband Age	The age of the husband in the household.
Wife Age	The age of the wife in the household.
Male Breadwinner	Takes a value of 1 if the primary breadwinner of the household is the husband and 0 otherwise.
Number of Dependent Children	The number of children below 24 years old in the household.
Deposits	The amount of household bank deposits, capitalized from taxable interest income using the market deposit rate. Preferential deposits of civil servants are capitalized using the applicable preferential interest rate.
Bonds	The amount of bond holdings in NT$, capitalized from taxable interest income.
Stock Holdings	The amount of stock holdings of the household in NT$. Publicly-traded stocks are valued at the market closing price on their ex-rights date (31 July if the ex-rights date is not available); also, non-publicly-traded stocks are priced at the net asset value per share (if available) or face value.
SMP_{it} (Stock Market Participation)	An indicator equal to one if household i holds stocks in year t and zero otherwise.
Present Value of Cars	The present value of cars in NT$ approximated by the documented engine size and brand.
Assessed Value of Real Estate	The assessed value of buildings and land in NT$ minus estimated outstanding mortgages.
$\text{Real Estate Owner}_{it}$ (Real Estate Ownership)	An indicator equal to one if household i holds real estate in year t and zero otherwise.
Mortgage	The household's outstanding mortgages in NT$. We distribute the aggregate mortgage amount proportionally to each household based on its share of aggregate household mortgage interest.
Total Wealth	The total wealth of the household in NT$, calculated as the sum of Deposits, Bonds, Stock Holdings, Present Value of Cars, and Assessed Value of Real Estate.
Deposit-to-Wealth Ratio	Deposits divided by Total Wealth.
Stock-to-Wealth Ratio	Stock Holdings divided by Total Wealth.
$A_{i,t+1}$ (Active Adjustment)	The observed stock-to-wealth ratio in year $t+1$ minus the no-trade stock-to-wealth ratio in year $t+1$. The no-trade ratio is constructed by revaluing the year-t stock portfolio using changes in stock closing prices between the two annual observation dates while holding other wealth fixed.

Continued on next page

Table A1 continued

Variable	Definition
$P_{i,t+1}$ (Passive Valuation)	The no-trade stock-to-wealth ratio in year $t+1$ minus the observed stock-to-wealth ratio in year t. It measures the change in stock exposure generated by closing-price changes in the baseline portfolio.
$p_{i,t+1}$ (Passive Log Stock-to-Wealth Change)	The log change from the observed stock-to-wealth ratio in year t to the no-trade stock-to-wealth ratio in year $t+1$. The no-trade value of the baseline stock portfolio is computed using changes in stock closing prices between the two annual observation dates.
$a_{i,t+1}$ (Active Log Stock-to-Wealth Change)	The logarithm of the observed stock-to-wealth ratio divided by the no-trade stock-to-wealth ratio. It measures the change in stock exposure relative to the closing-price-based no-trade counterfactual.
CivilServant_i (Civil Servant Indicator)	An indicator equal to one if the household breadwinner received annual working income exceeding NT$360,000 from public institutions for more than seven years and zero otherwise.
Post_t (Post-Reform Period)	An indicator equal to one from 2017 onward and zero otherwise.
Realized Gains	The monetary value of gains realized in NT$, identified through year-over-year changes in stock holdings and corresponding stock prices.
Realized Losses	The monetary value of losses realized in NT$, identified through year-over-year changes in stock holdings and corresponding stock prices.
Paper Gains	The unrealized gains in NT$ calculated based on year-over-year changes in stock holdings and corresponding stock prices.
Paper Losses	The unrealized losses in NT$ calculated based on year-over-year changes in stock holdings and corresponding stock prices.
Proportion of Gains Realized	The ratio of realized gains to the sum of realized gains and paper gains.
Proportion of Losses Realized	The ratio of realized losses to the sum of realized losses and paper losses.
Event-Time Indicator, $\mathbb{1}\{t-2017=j\}$	An indicator equal to one if the observation year is $2017+j$ and zero otherwise.
Total Risk Premium	The value-weighted average prior-year realized return of the household's stock portfolio net of the risk-free rate.

This table defines the variables used in the empirical analysis. Monetary variables are measured at the household level in NT$ unless otherwise indicated.

Table A2: Full Distributional Summary Statistics in the Pre-Reform Period (2013–2016)

Panel A: Population Variable	*N*	Mean	SD	p5	p25	p50	p75	p95
Husband Age	434,441	60.75	3.89	55.00	57.00	60.00	64.00	67.00
Wife Age	434,441	57.45	5.06	50.00	54.00	57.00	61.00	65.00
Male Breadwinner	434,441	0.73	0.44	0.00	0.00	1.00	1.00	1.00
Working After Retirement	434,441	0.45	0.50	0.00	0.00	0.00	1.00	1.00
Number of Dependent Children	434,441	0.32	0.65	0.00	0.00	0.00	0.00	2.00
ln(1 + Deposits)	434,441	8.38	7.22	0.00	0.00	12.43	14.80	16.69
Deposits (thousands)	434,441	3,313.36	9,678.31	0.00	0.00	249.64	2,683.89	17,764.33
ln(1 + Bonds)	434,441	0.01	0.21	0.00	0.00	0.00	0.00	0.00
Bonds (thousands)	434,441	2.51	245.06	0.00	0.00	0.00	0.00	0.00
ln(1 + Stock Holdings)	434,441	8.51	6.25	0.00	0.00	11.11	13.77	15.78
Stock Holdings (thousands)	434,441	2,099.44	42,158.25	0.00	0.00	67.02	957.69	7,150.00
SMP	434,441	0.68	0.47	0.00	0.00	1.00	1.00	1.00
ln(Stock Holdings) (Conditional)	295,670	5.65	2.54	0.96	3.96	6.07	7.53	9.20
Conditional Stock Holdings (thousands)	295,670	3,079.03	51,072.21	1.60	51.29	433.84	1,864.11	9,887.81
ln(1 + Present Value of Cars)	434,441	4.28	5.97	0.00	0.00	0.00	11.94	13.48
Present Value of Cars (thousands)	434,441	151.18	381.24	0.00	0.00	0.00	153.48	712.04
ln(1 + Assessed Value of Real Estate)	429,764	14.08	4.54	0.00	14.36	15.35	16.19	17.37
Assessed Value of Real Estate (thousands)	434,441	10,964.90	131,799.10	0.00	1,651.42	4,562.89	10,625.01	34,874.21
Real Estate Ownership	434,441	0.90	0.30	0.00	1.00	1.00	1.00	1.00
ln(1 + Mortgages)	434,441	1.44	4.30	0.00	0.00	0.00	0.00	14.30
Mortgage (thousands)	434,441	295.57	2,992.02	0.00	0.00	0.00	0.00	1,624.14
ln(1 + Total Wealth)	431,950	15.10	3.39	9.97	14.81	15.81	16.69	17.78
Total Wealth (thousands)	434,441	16,531.38	171,123.03	5.58	2,638.20	7,296.24	17,669.07	52,438.89
Deposit-to-Wealth Ratio	418,327	0.18	0.85	0.00	0.00	0.04	0.29	0.76
Stock-to-Wealth Ratio	418,327	0.12	3.25	0.00	0.00	0.01	0.11	0.60
Conditional Stock-to-Wealth Ratio	295,288	0.16	3.86	0.00	0.01	0.05	0.18	0.75
Active Log Stock-to-Wealth Change	295,670	0.39	1.22	-0.55	0.00	0.00	0.48	2.46
Passive Log Stock-to-Wealth Change	295,670	-0.45	1.01	-2.18	-0.49	-0.15	0.00	0.05
Proportion of Realized Gains	295,670	0.18	0.33	0.00	0.00	0.00	0.12	1.00
Proportion of Realized Losses	295,670	0.13	0.29	0.00	0.00	0.00	0.00	0.99
Realized Gains (thousands)	295,670	57.90	797.16	0.00	0.00	0.00	2.53	199.63
Realized Losses (thousands)	295,670	31.01	521.17	0.00	0.00	0.00	0.00	87.87
Paper Gains (thousands)	295,670	85.84	2,967.84	0.00	0.00	0.00	11.32	209.52
Paper Losses (thousands)	295,670	54.03	1,290.91	0.00	0.00	0.00	5.81	154.83
Total Risk Premium	295,670	3.75	27.29	-28.79	-8.03	0.00	11.11	42.32
Number of Children	434,441	2.35	1.04	0.00	2.00	2.00	3.00	4.00
Civil Servant	434,441	0.13	0.34	0.00	0.00	0.00	0.00	1.00

Table A2 (continued)

Panel B: Civil Servant Variable	*N*	Mean	SD	p5	p25	p50	p75	p95
Husband Age	56,147	61.41	3.99	55.00	58.00	61.00	65.00	68.00
Wife Age	56,147	58.39	4.95	51.00	55.00	58.00	62.00	66.00
Male Breadwinner	56,147	0.86	0.35	0.00	1.00	1.00	1.00	1.00
Working After Retirement	56,147	0.30	0.46	0.00	0.00	0.00	1.00	1.00
Number of Dependent Children	56,147	0.28	0.60	0.00	0.00	0.00	0.00	2.00
ln(1 + Deposits)	56,147	10.97	6.39	0.00	9.10	13.78	15.33	16.84
Deposits (thousands)	56,147	4,407.00	8,273.00	0.00	8.98	966.60	4,554.00	20,621.00
ln(1 + Bonds)	56,147	0.00	0.12	0.00	0.00	0.00	0.00	0.00
Bonds (thousands)	56,147	0.43	34.23	0.00	0.00	0.00	0.00	0.00
ln(1 + Stock Holdings)	56,147	8.83	6.00	0.00	0.00	11.43	13.67	15.50
Stock Holdings (thousands)	56,147	1,242.00	5,164.00	0.00	0.00	92.10	863.00	5,364.00
SMP	56,147	0.71	0.45	0.00	0.00	1.00	1.00	1.00
ln(Stock Holdings) (Conditional)	40,117	5.50	2.42	0.97	3.90	5.96	7.27	8.85
Conditional Stock Holdings (thousands)	40,117	1,728.00	5,991.00	1.64	48.20	387.30	1,429.00	6,942.00
ln(1 + Present Value of Cars)	56,147	4.90	6.13	0.00	0.00	0.00	12.33	13.42
Present Value of Cars (thousands)	56,147	155.20	318.40	0.00	0.00	0.00	225.80	675.50
ln(1 + Assessed Value of Real Estate)	55,650	14.85	3.41	11.34	14.70	15.53	16.26	17.33
Assessed Value of Real Estate (thousands)	56,147	10,352.00	21,460.00	0.00	2,352.00	5,485.00	11,393.00	33,272.00
Real Estate Ownership	56,147	0.95	0.22	0.00	1.00	1.00	1.00	1.00
ln(1 + Mortgages)	56,147	1.58	4.45	0.00	0.00	0.00	0.00	14.35
Mortgage (thousands)	56,147	266.90	1,425.00	0.00	0.00	0.00	0.00	1,710.00
ln(1 + Total Wealth)	55,924	15.73	2.30	13.51	15.22	16.05	16.83	17.72
Total Wealth (thousands)	56,147	16,157.00	25,999.00	646.60	4,023.00	9,316.00	20,325.00	49,753.00
Deposit-to-Wealth Ratio	55,361	0.24	0.92	0.00	0.00	0.13	0.42	0.79
Stock-to-Wealth Ratio	55,361	0.08	0.41	0.00	0.00	0.01	0.08	0.39
Conditional Stock-to-Wealth Ratio	40,095	0.11	0.48	0.00	0.01	0.04	0.12	0.47
Active Log Stock-to-Wealth Change	40,117	0.30	1.07	-0.71	0.00	0.08	0.44	1.87
Passive Log Stock-to-Wealth Change	40,117	-0.37	0.78	-1.35	-0.48	-0.21	0.00	0.09
Proportion of Realized Gains	40,117	0.20	0.35	0.00	0.00	0.00	0.25	1.00
Proportion of Realized Losses	40,117	0.14	0.31	0.00	0.00	0.00	0.01	1.00
Realized Gains (thousands)	40,117	48.88	358.30	0.00	0.00	0.00	6.61	202.70
Realized Losses (thousands)	40,117	26.30	394.40	0.00	0.00	0.00	0.09	92.76
Paper Gains (thousands)	40,117	51.70	463.90	0.00	0.00	0.02	13.94	197.70
Paper Losses (thousands)	40,117	40.71	486.40	0.00	0.00	0.00	8.00	153.90
Total Risk Premium	40,117	4.04	26.62	-28.54	-8.62	0.00	12.46	42.31

Table A2 (continued)

Panel C: Private Sector Variable	*N*	Mean	SD	p5	p25	p50	p75	p95
Husband Age	378,294	60.65	3.86	55.00	57.00	60.00	64.00	67.00
Wife Age	378,294	57.31	5.06	50.00	54.00	57.00	61.00	65.00
Male Breadwinner	378,294	0.71	0.45	0.00	0.00	1.00	1.00	1.00
Working After Retirement	378,294	0.47	0.50	0.00	0.00	0.00	1.00	1.00
Number of Dependent Children	378,294	0.32	0.66	0.00	0.00	0.00	0.00	2.00
ln(1 + Deposits)	378,294	8.00	7.25	0.00	0.00	11.97	14.71	16.66
Deposits (thousands)	378,294	3,151.00	9,860.00	0.00	0.00	158.50	2,452.00	17,185.00
ln(1 + Bonds)	378,294	0.01	0.22	0.00	0.00	0.00	0.00	0.00
Bonds (thousands)	378,294	2.82	262.30	0.00	0.00	0.00	0.00	0.00
ln(1 + Stock Holdings)	378,294	8.46	6.29	0.00	0.00	11.05	13.79	15.82
Stock Holdings (thousands)	378,294	2,227.00	45,133.00	0.00	0.00	63.25	978.10	7,451.00
SMP	378,294	0.67	0.47	0.00	0.00	1.00	1.00	1.00
ln(Stock Holdings) (Conditional)	255,553	5.68	2.55	0.96	3.97	6.10	7.58	9.24
Conditional Stock Holdings (thousands)	255,553	3,291.00	54,881.00	1.60	51.97	443.90	1,962.00	10,318.00
ln(1 + Present Value of Cars)	378,294	4.18	5.94	0.00	0.00	0.00	11.92	13.48
Present Value of Cars (thousands)	378,294	150.60	389.70	0.00	0.00	0.00	150.40	717.80
ln(1 + Assessed Value of Real Estate)	374,114	13.96	4.67	0.00	14.30	15.32	16.18	17.38
Assessed Value of Real Estate (thousands)	378,294	11,056.00	140,999.00	0.00	1,550.00	4,427.00	10,484.00	35,089.00
Real Estate Ownership	378,294	0.90	0.30	0.00	1.00	1.00	1.00	1.00
ln(1 + Mortgages)	378,294	1.43	4.27	0.00	0.00	0.00	0.00	14.29
Mortgage (thousands)	378,294	299.80	3,159.00	0.00	0.00	0.00	0.00	1,611.00
ln(1 + Total Wealth)	376,026	15.00	3.51	8.98	14.74	15.77	16.67	17.79
Total Wealth (thousands)	378,294	16,587.00	183,109.00	1.70	2,457.00	6,997.00	17,215.00	52,929.00
Deposit-to-Wealth Ratio	362,966	0.17	0.84	0.00	0.00	0.03	0.27	0.75
Stock-to-Wealth Ratio	362,966	0.12	3.48	0.00	0.00	0.01	0.12	0.63
Conditional Stock-to-Wealth Ratio	255,193	0.17	4.15	0.00	0.01	0.05	0.19	0.78
Active Log Stock-to-Wealth Change	255,553	0.40	1.24	-0.52	0.00	0.00	0.48	2.56
Passive Log Stock-to-Wealth Change	255,553	-0.46	1.05	-2.29	-0.49	-0.14	0.00	0.04
Proportion of Realized Gains	255,553	0.17	0.33	0.00	0.00	0.00	0.10	1.00
Proportion of Realized Losses	255,553	0.12	0.29	0.00	0.00	0.00	0.00	0.99
Realized Gains (thousands)	255,553	59.31	845.60	0.00	0.00	0.00	2.03	199.10
Realized Losses (thousands)	255,553	31.75	538.40	0.00	0.00	0.00	0.00	87.18
Paper Gains (thousands)	255,553	91.20	3,187.00	0.00	0.00	0.00	10.89	212.00
Paper Losses (thousands)	255,553	56.12	1,375.00	0.00	0.00	0.00	5.51	155.00
Total Risk Premium	255,553	3.70	27.40	-28.86	-7.90	0.00	10.88	42.32

This table presents the distribution of the variables in the pre-reform period from 2013 to 2016. Panel A reports statistics for the full population, Panel B for civil servant households, and Panel C for private sector households. Monetary amounts reported in thousands are in NT$. The columns report the number of observations, mean, standard deviation, and selected percentiles. Conditional Stock Holdings and Conditional Stock-to-Wealth Ratio are calculated among households with positive stock holdings; the latter also requires a nonmissing ratio. The unconditional ratio is reported separately. All variables are defined in Table A1.

B Reference-Dependent Model Extensions

B1 Habit persistence in the Merton framework

An important extension of the standard Merton framework incorporates persistent habits, consumption commitments, or subsistence consumption (Brunnermeier and Nagel, 2008; Calvet and Sodini, 2014). In Calvet and Sodini (2014), the optimal risky share admits a closed-form expression when taking habits into account:

$$\alpha = \left(1 + \frac{PV(Y) - \kappa X}{W}\right) \frac{\mu - r}{\gamma \sigma^2}, \tag{17}$$

in which X denotes the persistent habit, consumption commitment, or subsistence level, and $\kappa > 0$ is a constant such that κX captures the present value of sustaining the habit over the agent's lifetime. Under this model, the effect of a change in permanent income on the risky share is:

$$\frac{\partial \alpha}{\partial PV(Y)} = \frac{1}{W} \frac{\mu - r}{\gamma \sigma^2} > 0. \tag{18}$$

Thus, as in the baseline Merton framework, the habit-persistence model predicts that a reduction in pension income should decrease the risky share. This prediction goes in the opposite direction of our empirical finding that retired civil servants increase their stock-to-wealth ratios after the reform.

B2 Break-even motive

Proof of Proposition 1. For $a_i < G_i/g$, consumption remains below the reference point in both payoff states. Expected utility is therefore

$$E[u(C_i(a_i, X; P_i))] = -\lambda G_i + \lambda a_i \big[pg - (1-p)\ell\big],$$

which is strictly increasing in a_i under Assumption 1. For $a_i > G_i/g$, the good state is above the reference point while the bad state remains below it, so

$$E[u(C_i(a_i, X; P_i))] = -\big[p + \lambda(1-p)\big] G_i + a_i \big[pg - \lambda(1-p)\ell\big].$$

This expression is strictly decreasing in a_i under Assumption 1. Without the portfolio-reallocation capacity bound, expected utility therefore increases up to the kink G_i/g and decreases thereafter. On the feasible interval $[0, L_i]$, the unique maximizer is consequently $a_i^* = \min\{G_i/g, L_i\}$. A larger pension cut increases G_i and hence weakly increases a_i^*; the increase is strict whenever $G_i/g < L_i$. Holding the pension cut fixed, a larger L_i also weakly increases a_i^*; the increase is strict whenever $L_i < G_i/g$. □

B3 Total risk premium and extrapolative beliefs

The total risk premium is defined in Equation (13) as stock s's realized annual return in year $t-1$ net of the realized annual risk-free return. It is information available before

the portfolio observed in year t, but it is not an estimate of the stock's objective expected return. Assumption 2 specifies that the household maps this realized performance into the perceived favorable-state payoff $\widehat{g}_{s,t} = h(R^{\text{PR}}_{s,t-1})$, with $h' > 0$, while holding p and $-\ell$ fixed. This formulation isolates favorable-state extrapolation. Allowing stronger past performance also to raise p or reduce ℓ would reinforce the preference for the stock, but could move the optimum to the portfolio-reallocation capacity bound.

Proof of Proposition 2. For any fixed feasible $a_i > 0$, an increase in $R^{\text{PR}}_{s,t-1}$ raises $\widehat{g}_{s,t}$ under $h' > 0$. It therefore raises consumption in the favorable state and leaves consumption in the unfavorable state unchanged. Because the value function is increasing in consumption, expected utility is weakly increasing in $R^{\text{PR}}_{s,t-1}$. Maximizing over the same feasible set preserves this ordering. For $G_i > 0$, direct differentiation gives

$$\frac{\partial}{\partial R^{\text{PR}}_{s,t-1}} \left(\frac{G_i}{h(R^{\text{PR}}_{s,t-1})} \right) = -\frac{G_i h'(R^{\text{PR}}_{s,t-1})}{h(R^{\text{PR}}_{s,t-1})^2} < 0.$$

Thus, conditional on extrapolation, a stock with a higher total risk premium provides greater optimized utility and requires a smaller investment to reach the pre-reform reference point in the favorable state. □

C Additional Empirical Evidence

C1 Baseline characteristics by child groups

Table C1 reports pre-reform summary statistics separately by the number of dependent children and by the total number of children. The first classification captures current child-related consumption commitments, while the second includes adult children and is therefore more closely related to the number of potential heirs.

Table C1: Baseline Characteristics by Child Group

	Number of Dependent Children			Total Number of Children		
	0	1	≥ 2	0	1	≥ 2
Total Wealth (NT$ thousands)	16,815.3	15,361.7	16,005.9	14,738.3	22,099.3	16,083.4
Stock Market Participation, $\mathbb{1}\{\text{Stock Holdings} > 0\}$	0.676	0.685	0.681	0.637	0.713	0.677
Stock Holdings (NT$ thousands)	2,026.0	2,215.5	2,625.7	2,966.1	3,499.8	1,891.0
Conditional Stock Holdings (NT$ thousands)	2,977.4	3,220.2	3,840.8	4,623.5	4,882.0	2,776.0
Stock-to-Wealth Ratio	0.115	0.113	0.128	0.146	0.135	0.111
Deposit-to-Wealth Ratio	0.189	0.155	0.137	0.177	0.202	0.178
Active Log Stock-to-Wealth Change	0.0224	0.0192	0.0191	0.0219	0.0269	0.0211
Passive Log Stock-to-Wealth Change	-0.0303	-0.0206	-0.0199	-0.0229	-0.0284	-0.0283
Observations	335,408	67,029	32,004	26,832	38,348	369,261

This table presents pre-reform means for households grouped by the number of dependent children and by the total number of children. Dependent children are children below 24 years old, while the total number of children includes adult children. Monetary amounts reported in thousands are in NT$.

C2 Subgroup analysis based on all children

Table C2 repeats the subgroup analysis using the total number of children, including adult children. For the logarithm of the stock-to-wealth ratio, the estimates are 0.144, 0.162, and 0.0997 for households with no children, one child, and two or more children, respectively. The corresponding estimates for the logarithm of stock holdings are 0.0742, 0.106, and 0.0567. The estimates do not increase monotonically with the total number of children. This pattern differs from the dependent-child results and does not support the interpretation that treated households increase stock holdings primarily to leave larger bequests.

Table C2: Subgroup Analysis Based on the Total Number of Children

	(1)	(2)	(3)
Total Number of Children	0	1	≥ 2
Panel A: Logarithm of the Stock-to-Wealth Ratio			
Civil Servant×Post	0.144***	0.162***	0.0997***
	(0.0502)	(0.0355)	(0.0112)
Observations	40,187	68,915	616,964
R^2	0.0384	0.0283	0.0334
Panel B: Logarithm of Stock Holdings			
Civil Servant×Post	0.0742	0.106***	0.0567***
	(0.0471)	(0.0337)	(0.0109)
Observations	40,297	69,064	618,580
R^2	0.0236	0.0200	0.0200
Household Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Time-Varying Controls	Yes	Yes	Yes
Financial Controls × Year FE	Yes	Yes	Yes

This table examines whether the effect of the 2017 pension reform varies with the total number of children, including adult children. Panel A reports estimates for the logarithm of the stock-to-wealth ratio, and Panel B reports estimates for the logarithm of stock holdings. Each column estimates Equation (1) for the indicated subgroup using the preferred specification, which includes household and year fixed effects, the time-varying controls, and the financial controls interacted with year indicators. Standard errors are clustered at the household level and are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

C3 Additional disposition-effect measures

Table C3 reports estimates using the Proportion of Gains Realized and the Proportion of Losses Realized. The former is realized gains divided by the sum of realized and paper gains, while the latter is realized losses divided by the sum of realized and paper losses. In the preferred specification, the coefficient on $\text{CivilServant}_i \times \text{Post}_t$ is 0.00579 for the Proportion of Gains Realized and 0.00124 for the Proportion of Losses Realized. Only the estimate for the Proportion of Gains Realized is statistically significant.

Table C3: Additional Disposition-Effect Measures

	(1)	(2)	(3)
Panel A: Proportion of Gains Realized			
Civil Servant×Post	0.00650***	0.00942***	0.00579**
	(0.00237)	(0.00236)	(0.00238)
R^2	0.0363	0.0427	0.0447
Panel B: Proportion of Losses Realized			
Civil Servant×Post	0.00125	0.00329	0.00124
	(0.00212)	(0.00211)	(0.00213)
R^2	0.0125	0.0164	0.0181
Household Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Time-Varying Controls	No	Yes	Yes
Financial Controls × Year FE	No	No	Yes
Observations	731,098	731,098	727,941

This table examines the effect of the 2017 pension reform on the Proportion of Gains Realized and the Proportion of Losses Realized. The sample consists of households that held stocks before the reform. Column (1) includes household and year fixed effects. Column (2) adds the time-varying controls. Column (3) additionally includes the financial controls interacted with year indicators. Standard errors are clustered at the household level and are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

C4 Matched-sample robustness

To address differences in pre-reform characteristics, we match each retired civil servant household with its three nearest private sector counterparts using Mahalanobis distance. The matching variables, measured in 2016, are husband age, wife age, the indicator MaleBreadwinner, the number of dependent children, the logarithm of one plus deposits, the logarithm of one plus stock holdings, the logarithm of one plus total wealth, the deposit-to-wealth ratio, and the stock-to-wealth ratio.

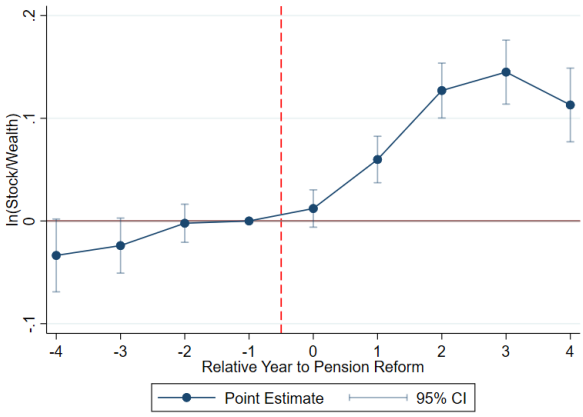
Table C4 reports summary statistics for the matched sample. Average total wealth is NT$16.527 million (approximately US$550,900) for treated households and NT$16.566 million (approximately US$552,200) for matched controls; the stock market participation rates are 0.70 and 0.71, and the stock-to-wealth ratios are 0.07 and 0.08.

Table C4: Summary Statistics for the Matched Sample

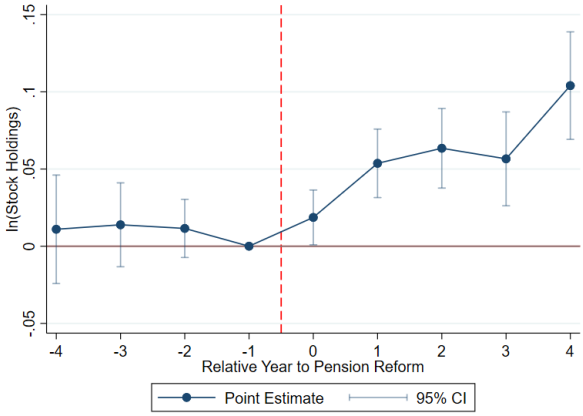
	Civil Servants	Private Sector	Difference
Husband Age	62.10	61.95	-0.15***
Wife Age	59.06	58.88	-0.18***
MaleBreadwinner	0.86	0.86	-0.00
Number of Dependent Children	0.25	0.25	-0.01
Deposits (NT$ thousands)	4,219.61	4,304.05	84.45
Bonds (NT$ thousands)	0.05	0.68	0.63**
Stock Holdings (NT$ thousands)	1,195.06	1,330.74	135.68**
Conditional Stock Holdings (NT$ thousands)	1,704.32	1,875.09	170.76**
SMP (Stock Market Participation)	0.70	0.71	0.01*
Present Value of Cars (NT$ thousands)	152.23	154.37	2.14
Assessed Value of Real Estate (NT$ thousands)	10,959.83	10,776.27	-183.56
RealEstateOwner	0.95	0.97	0.02***
Mortgage (NT$ thousands)	287.09	254.17	-32.92**
Total Wealth (NT$ thousands)	16,526.78	16,566.12	39.34
Deposit-to-Wealth Ratio	0.23	0.22	-0.01**
Stock-to-Wealth Ratio	0.07	0.08	0.00
Conditional Stock-to-Wealth Ratio	0.10	0.11	0.00
Active Log Stock-to-Wealth Change	0.29	0.35	0.06***
Passive Log Stock-to-Wealth Change	-0.34	-0.38	-0.04***
Observations	20,535	60,347	80,882

This table presents pre-reform means for retired civil servant households and their matched private sector counterparts. Each treated household is matched to its three nearest control households as described in the text. The final column reports the control mean minus the treatment mean. Conditional Stock Holdings and Conditional Stock-to-Wealth Ratio are calculated among households with positive stock holdings; the latter also requires a nonmissing ratio. Active and passive log changes refer to a and p, respectively. The observations row reports the overall matched sample, not variable-specific counts. Monetary amounts reported in thousands are in NT$. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

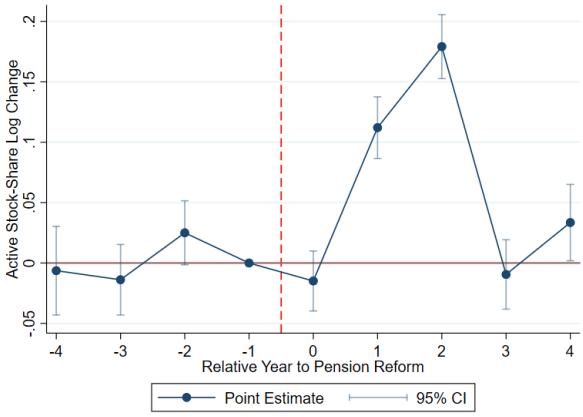
Figure C1 reports event-study estimates for all three principal outcomes. In the fully controlled specification, the 2021 estimates are 0.113 for the stock-to-wealth ratio, 0.104 for stock holdings, and 0.0335 for the active log stock-to-wealth change. The matched-sample patterns are therefore similar to those in the full sample.



(a) Logarithm of the stock-to-wealth ratio



(b) Logarithm of stock holdings



(c) Active log stock-to-wealth change

Figure C1: Robustness Checks Using the Matched Sample

This figure presents event-study estimates using the matched sample. Panels (a), (b), and (c) report estimates for the logarithm of the stock-to-wealth ratio, the logarithm of stock holdings, and the active log stock-to-wealth change, respectively. The dots represent point estimates, and the bars denote 95% confidence intervals. Relative Year 0 corresponds to 2017, when the reform legislation was passed, and Relative Year 1 corresponds to 2018, when the pension cuts began. The omitted relative year is −1.