Pension Reform and Asset Allocation:

Evidence from Annuity Cuts to Retired Civil Servants in Taiwan

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June 15, 2025

Abstract

How do households reallocate assets when faced with a sudden decrease in lifetime income? We examine retired civil servants' asset allocation in response to a *retroactive* pension cut in Taiwan. Using administrative tax data, we show that these retirees increased their stock-to-wealth ratios by 10%, stock holdings by 7%, and risk exposures to market and other risks following the annuity cuts. Moreover, they exhibited a heightened disposition effect, reduced their bank deposits and total wealth, and were more likely to re-enter the labor market. Our large-scale evidence suggests that, consistent with prospect theory, retirees pursued riskier assets under annuity cuts.

Keywords: pension reforms; retirement annuity; stock market participation; asset allocation; prospect theory; household finance.

JEL codes: D14, G11, G50, H55, J32

We thank Kuan-Ming Chen, Chun-Che Chi, Chun-Fang Chiang, James Choi, Hunghua Pan, Kai-Jyun Wang and seminar participants at National Tsing Hua University and National Taiwan University for valuable comments. We are grateful to the Fiscal Information Agency (FIA) of the Ministry of Finance, Taiwan, for providing us with our data.

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1. Introduction

The allocation of assets, and particularly the weight of risky ones, has been a core research question in household finance (Campbell, 2006; Beshears et al., 2018; Gomes, Haliassos, and Ramadorai, 2021). The holdings of risky assets are subject to various demographic characteristics such as age, gender, and health (Rosen and Wu, 2004; Curcuru et al., 2010; Addoum, 2017; Choi and Robertson, 2020). Among all these characteristics, household wealth is found to play a particularly important role.[1]

However, as household wealth hinges on many factors and decisions, it is often challenging to draw causal inferences for its effect on asset allocations. In this paper, we focus on retirees because they have limited income sources and pensions constitute a large share of their wealth. Moreover, the heightened pension obligations driven by an aging population in many countries have led to pension reforms that substantially reduce the benefits received by retirees (Lindbeck and Persson, 2003; OECD, 2019, 2021, 2023). There is, however, little evidence on pension reforms' influence on asset allocation decisions despite the long-lasting impact of such policy changes on household finance (Scharfstein, 2018; Zhang, 2021).[2]

Existing theoretical literature offers *opposite* predictions for the effect of pension reforms on retirees' asset allocations. On the one hand, some prior studies suggest retirees' stock holdings to *reduce* after pension cuts. For instance, Guiso and Paiella (2008) and Calvet and Sodini (2014) provide evidence on decreasing relative risk aversion (DRRA).[3] Moreover, Zhang (2021) documents that residents in states with higher pension deficits hold fewer stocks and more safe deposits.

On the other hand, a growing body of empirical research documents a wide range of behavioral biases that deviate from the predictions of standard economic models in households' financial decisions (Odean, 1998, 1999; Beshears et al, 2018; Stango and Zinman, 2023; Olafsson

[1] Levy's (1994) experimental evidence suggests that subjects invest more wealth in risky assets as wealth increases. Supportive evidence is reported in Friend (1973), Blume, Crockett, and Friend (1974), Cohn et al. (1975), Guiso, Jappelli, and Terlizzese (1996), and Addoum (2017).

[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. Most reforms target the entire population or impose gradual changes over extended periods, challenging researchers' ability to design identification strategies.

[3] A negative relation between risky asset holding and future income risk has been documented and modeled in Guiso, Jappelli, and Terlizzese (1996), Heaton and Lucas (2000a, 2000b), and Knüpfer, Rantapuska, and Sarvimäki (2017).

and Pagel, 2024, 2025). According to prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992), individuals tend to be risk-seeking in the domain of losses relative to their reference point (Page, Savage, and Torgler, 2014; Lian, Ma, and Wang, 2019). Once retirees experience losses (relative to their previous living expenses) under pension cuts, they could pursue riskier assets in their asset allocations.

To empirically test the opposite predictions based on prior literature, we exploit one of the most radical pension reforms in history – the pension reform of civil servants in Taiwan in 2017 – as well as comprehensive, administrative data of household wealth in Taiwan. According to the reform legislation, the retirement annuities of civil servants in Taiwan will be drastically reduced: the income replacement rate will be reduced from the 75%-95% range to the 30%-62.5% range. However, other retirees are totally unaffected around the reform period. More importantly, this reform is *retroactively* applied to former civil servants who have already retired and live on retirement annuities. This directly nullifies the government's promise and thus contravenes the usual "Grandpa Clause" in pension obligations. Given the retroactive feature and the drastic cut, the sudden occurrence and the extent of the annuity cuts lead to a *permanent* income reduction of retired civil servants.

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, which amounted to 8% of total employees. Secondly, being a civil servant is regarded as a stable job with a high entry barrier. Individuals who intend to serve in the government will need to pass rigorous examinations (the pass rate was only 9.31% in 2016) together with other corresponding training programs, if they are to qualify. After formal recruitment, while there are elimination mechanisms, it is rare for civil servants to be laid off due to poor performance or government restructuring. Thus, it is very common for civil servants to remain in government employment until their retirement age. (In 2020, the turnover rate of civil servants is only 0.68%.) Finally, civil servants will receive retirement annuities after they retire, which are determined based on their tenure and pre-retirement salary levels.[4] Before the pension reform in 2017, such annuities were considered to be generous.

[4] Although retired civil servants can choose to cash out their pension in a lump sum at upon retirement (which is irreversible), such an option is rarely exercised (less 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

To compile the data on the allocation of all households' assets, 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 taxable asset categories, namely, houses (i.e., buildings), land, stock shares, bank deposits, bonds, and cars. We have managed to collect comprehensive, detailed data on almost all individuals' and households' occupations, wealth, and income in Taiwan from 2005 to 2021.

We design a difference-in-differences setting to examine whether retired civil servants react to the pension reform in terms of asset allocation differently from other retirees. We focus on households with only one working individual who retired before the pension reform,[5] 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, their annuities and pension plans are fixed and thus not subject to uncertainty, and their human capital and future labor income are largely negligible.

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 (Guiso, Haliassos, and Jappelli, 2002; Addoum, 2017; Zhang, 2021). 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 imposes 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 sample.

We use the total value of stock holdings and stock-to-wealth ratio to measure a household's holding of risky assets (Guiso, Haliassos, and Jappelli, 2002; Addoum, 2017; Zhang, 2021). These two measures are free from modeling and/or estimation errors, and are commonly used in the

due to not serving a sufficient tenure length. 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 such as discussed in Hurwitz and Sade (2025).

[5] 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 aged between 55 and 70 years.

literature. We find that, in comparison with other households, those of retired civil servants increase their stock-to-wealth ratios by more than 10% with statistical significance after the reform. In addition, retired civil servants increase their value of stock holdings by more than 7% with statistical significance after the reform. These results support the reduced risk aversion in the loss domain as predicted by prospect theory.

Additional analyses suggest that there is no pre-trend in the treated group's (i.e., retired civil servants') stock holdings, supporting the view that the parallel trend assumption is satisfied. Furthermore, we perform two robustness checks. First, we construct a matched control group similar to retired civil servants based on observable characteristics (especially the total wealth and the stock-to-wealth ratio) before the treatment. Using the subsample, we estimate the effects of pension reform on households' stock holdings and find consistent results. Second, we implement the pre-trend test proposed by Roth (2022), demonstrating that our findings are robust to potential violations of the parallel trend assumption.

We then investigate risk profiles of stocks held by each household to examine if retired civil servants invest more in riskier assets after the pension reform. Specifically, we first estimate each stock's risk exposures using three common risk factor models: the Capital Asset Pricing Model (CAPM), Fama-French three-factor model (FF3; Fama and French, 1993), and Fama-French five-factor model (FF5; Fama and French, 2015). We then show that the market beta of retired civil servants' portfolios increases by 13% to 15%, a result that is robust across all three models. We also find increased exposures to the size, value, and profitability factors in their portfolios. On the other hand, we do not find any significant difference in alphas and idiosyncratic volatility between the treated and control groups.

Our empirical evidence supports the predictions based on prospect theory as follows. The pension reform forced retired civil servants to choose between preserving their existing low-risk savings and enduring a permanent income cut, or reallocating their assets toward riskier stocks in pursuit of higher returns. Opting to maintain the status quo implies accepting a guaranteed loss, while shifting to a riskier portfolio offers the possibility of recovering the loss. Under prospect theory, the latter choice is more psychologically appealing (Page, Savage, and Torgler, 2014; Lian, Ma, and Wang, 2019), as it presents a chance to "break even" rather than settle for diminished wealth.

We further examine whether the annuity cuts led to the disposition effect—a well-documented behavioral bias associated with prospect theory—whereby investors are more inclined to sell winning stocks while holding onto losing ones (Shefrin and Statman, 1985; Odean, 1998; Barber et al., 2007). Our empirical findings indicate that retired civil servants displayed a more pronounced pattern of the disposition effect following the pension reform: the gap between realized gains and realized losses widened by approximately 42%.

We also validate retired civil servants' substantial wealth loss after the reform by considering other dimensions of household finance: In particular, we consider how households adjust their bank deposits and wealth, retirees' tendency to pursue a new job, and their financial pressure from young children. Treated households' deposits-to-wealth ratios and total wealth decrease by 22% and 3.67%, respectively, relative to those of other households following the reform. In addition, the ratio for treated retirees who look for another job is 4 percentage points higher than that for control retirees. Moreover, such an increase in stock holdings is more pronounced among treated households with more young children. These additional results collectively highlight the increased financial pressure faced by retired civil servants after the reform.

We have also considered several alternative explanations for the shift towards risky assets by retired civil servants after the reform. The first set of explanations is related to civil servants' time constraints, regulatory restrictions that prevent them from investing in stocks, and their lack of stock investment experience and knowledge. However, all these issues have existed before the reform; since our sample only includes retirees who retire *before* the pension reform, they thus cannot explain the change in the retirees' stock holdings right after the pension reform. Furthermore, retired civil servant households are more likely to hold stocks (69.2%) than private sector ones (66.1%) prior to the reform. Another plausible explanation is that civil servants switched from the preferential deposits with an 18% annual interest rate (which was gradually terminated after the reform) to stock holdings. Nevertheless, preferential deposits were still available with a 9% annual interest rate (which is way above most assets' expected returns after risk adjustment) until 2020, but the increases in the stock-to-wealth ratio and stock holdings occurred in 2017-2020. One more concern is that our results are driven by stock market conditions. However, the Taiwan stock market index was fairly stable in 2017-2019 (and then increased since

2020), and we have observed a significant increase in retired civil servants' stock holdings since 2017.

Our paper contributes to several strands of the economics and finance literature. First, it adds to the analyses of the impact of pension reforms in several ways. Differing from prior research in this area that focuses on saving rates (Feldstein, 1974; Attanasio and Brugiavini, 2003) and secondary jobs (Fisher and Keuschnigg, 2010), we focus on risky asset allocation that has important implications for financial markets due to the aging population (especially in Asian economies with extremely low birth rates). As baby boomers approach and enter their retirement years, how retirees allocate their wealth and the resultant policy implications has become an important research question (Beshears et al., 2011; Poterba, Venti, and Wise, 2011; Scharfstein, 2018). Our identification strategy is particularly effective because the pension reform we study is specific to civil servants and retroactively cuts annuities, while prior studies on pension reforms lack clear-cut treatment groups (Feldstein, 1974; Attanasio and Brugiavini, 2003; Attanasio and Rohwedder, 2003). Moreover, our administrative data are complete and comprehensive, while most prior studies tend to rely on surveys and/or selected samples.[6]

Second, this paper is related to a core research question in household finance: the determinants of stock market participation and risky asset holdings (e.g., Heaton and Lucas, 2000a, 2000b; Campbell, 2006; Curcuru et al., 2010). Our finding does not support a positive relation between risky asset holdings and net wealth; instead, it is consistent with a risk-seeking behavior in the loss domain based on prospect theory of Kahneman and Tversky (1979) and Tversky and Kahneman (1992).[7] Moreover, our large-scale, population-level results complement prior evidence based on experiments and surveys that may suffer from limited real impact, smaller sample size, and selection issues (Abdellaoui et al., 2008; Harbaugh et al., 2010; Lian, Ma, and Wang, 2019).[8]

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[6] 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).

[7] Another possible explanation for our finding is the increasing relative risk aversion (IRRA) hypothesis of Pratt (1964) and Arrow (1965). However, as Campbell (2006) notes, most prior evidence supporting IRRA is based on surveys and selected samples. Blume, Crockett, and Friend (1974) and Blume and Friend (1975) use a special sample of 17,056 individuals from the Internal Revenue Service (IRS) in the U.S. In contrast, Levy (1994) rules out the possibility of IRRA using an experimental design.

[8] Experiments often involve small stakes compared to real-life scenarios, the selection into sample raises concerns about external validity, and it is challenging to induce actual wealth loss in experimental settings due to inherent

Lastly, it is noteworthy that most prior population-level analyses of household labor and asset allocation are based on European countries, such as the Finnish data in Grinblatt and Keloharju (2000, 2001) as well as the Swedish data in Calvet, Campbell, and Sodini (2007) and Massa and Simonov (2006). In this paper, we present households' asset allocation from a new perspective. Taiwan households are featured for having high savings, owning residential property (78.6% own their residences), high family support, and low stock market participation (only half of the population had a stock account in 2021). The difference between our finding and Zhang's (2021) that is based on U.S. state-level pension deficits suggests that cultural issues and societal features may play important roles in households' stock holdings (e.g., Osili and Paulson, 2008; Haliassos, Jansson, and Karabulut, 2017).

2. Institutional Background

In Taiwan, civil servants cover the employees of all branches of the government, including the military and public-school education (but not including employees working for state-owned enterprises or government-sponsored institutes). 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 involves two components.[9] Firstly, the monthly pension and income replacement ratio are determined based on the duration of service. Secondly, civil servants are provided with the opportunity to save in a preferential deposit account that offers an 18% annual interest rate. We provide more details on this in Appendix Section A.1. In general, civil servants are assured a minimum income replacement ratio of 75% with the potential to reach up to 95% (as shown in the top row of Table A1 in the Appendix). This generous pension plan, however, creates a huge burden for the government: the total payout to civil servant retirees was 310.8 billion New Taiwan Dollars (NTD) in the year 2016.

On June 27, 2017, the "Civil Servants Retirement, Severance, and Dismissal Compensation Act" was passed by the Legislative Yuan (which is analogous to the two chambers in the U.S.). This pivotal 2017 pension reform aimed to reduce the government's financial burden imposed by the pension systems for military personnel and civil servants. The reform consisted of the

difficulties (Levitt and List, 2007; Harrison and Rutström, 2008; Wakker, 2010; Page, Savage, and Torgler, 2014).

[9] The Public Officials Retirement Act.

following five major parts: (1) the normal retirement age was raised; (2) the pension calculation formula was adjusted; (3) the 18% preferential interest rate, which used to be a part of retired civil servants' annuities, was gradually reduced 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 Section A.2. A significant reduction in the income replacement ratio started to be implemented in June 2018; in addition, the ratio was to be reduced by an increment of 1.5% every year from 2020 to 2029.[10] In 2029, the income replacement ratio will fall to the 30%-62.5% range (as shown in the bottom row of Table A1 in the Appendix). As a result, the income replacement ratio will in the end be cut by 27.5% to 45%, with civil servants with shorter lengths of service experiencing more severe cuts. In addition, the actual cut may in fact be deeper because the calculation does not account for the change from the base salary to the average base salary for the last fifteen years at work, and so the actual income replacement ratio can be lower than the 27.5%-45% range.[11]

This pension reform effectively reduced the financial burden for governments. For instance, the total payout to retired civil servants was reduced by 13.5 billion NTD in 2020.[12] The reform is expected to reduce the government's obligation to provide retirement annuities by 1.42 trillion NTD over the next 50 years.

3. Data and Summary Statistics

3.1 Data sources

Our main data source is the 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 consists of deposits, bonds, stocks, housing, land, and car ownership information (serving for property tax collection) from 2003 to 2021, and (2) the Personal Income Tax database, which consists of all taxable salaries, income from professional practice, bonuses, dividends, bank

[10] However, there is an exception. In order to guarantee a certain standard of living, individuals whose monthly pension falls below 33,140 NTD after the reform will receive a minimum of 33,140 NTD.
[11] Prior to the reform, the income replacement ratio was based on the salary before retirement. After the reform, the base for calculating the income replacement ratio gradually transitioned to the average base salary of the last fifteen years of employment. Consequently, if a civil servant received a promotion during his/her last fifteen years of employment, the average base salary would be lower than the initial base salary before the reform. As a result, the reduction in the annuity is actually larger than the range from 27.5% to 45%.
[12] Data Source: Ministry of Civil Service.

deposit interest, bond interest, and other personal income items in annual tax filings from 2001 to 2021. All these datasets can be merged through unique anonymized ID numbers. Two key features of the Personal Income Tax database are noteworthy: first, the income filings are reported by employers, which enables us to extract the valuable information on employer-employee linkages (and to identify individuals who are civil servants). Second, a detailed item on mortgage interest is recorded for tax deduction purposes, which allows us to estimate the outstanding mortgages of the households.

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

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 non-profit organization whose main objective is to safeguard the security and stability of the financial system while also addressing the operational requirements of its member institutions. It collects, processes, and maintains the credit information of individuals and businesses, providing valuable 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 wealth in terms of real estate as the assessed value of the house and land minus the outstanding mortgage.

Lastly, we collect stock prices and returns from the Taiwan Economic Journal (TEJ) financial database. The TEJ database provides comprehensive firm-level information, including stock prices, outstanding shares, and trading volumes. It also reports market-wide factor returns,

enabling the estimation of asset pricing models such as the Capital Asset Pricing Model (CAPM), the Fama-French three-factor model, and the Fama-French five-factor model. By merging TEJ data with our household wealth data using anonymized stock ID, we construct detailed household-level information on stock holdings, portfolio characteristics, and realized gains and losses.

3.2 Sample formation and summary statistics

Given our focus on the 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 people retired before the pension reform so their retirement timing is not driven by the pension reform. Given that the pension reform is retroactively applied to former civil servants who had already retired, these retirees' annuities were cut permanently, which reduces their expected wealth. Second, focusing on single-earner families helps us rule out confounding factors such as the spouse's income status and retirement decision (Cullen and Grueber, 2000).[13] More importantly, the majority (about 75%) of households with individuals that retired in the 2011-2016 period are single-earner families. Hence, this refined sample of our study is representative of the population. Since most breadwinners in single-earner families in Taiwan are husbands, we further narrow our sample to include only families with husbands aged between 55 and 70 years old. This sample filter also ensures that our sample consists primarily of civil servants who retired with annuities. Among the 8,868 civil servants who retired in the age of 55 or older in 2016, only 163 (1.8%) opted to cash out their pension as a lump-sum payment.

We define an individual as retired in year t if s/he satisfies one of the following criteria: (i) s/he has received pension income in year t; (ii) an individual who was a civil servant is aged over 50 years old and does not receive any payment from the employer in year t;[14] (iii) an individual who has been employed by a non-public employer for more than 5 years is aged over 50 years old and does not receive any payment from the same employer in year t.

[13] If we consider a dual-earner household as retired when one of the couple is retired, the spousal labor supply could introduce potential confounding factors (such as delaying her/his retirement). Conversely, if we define a dual-earner household as retired only when both partners are retired, we might end up with a highly selective sample. In addition, the evidence suggests that leisure complementarity plays a significant role when the two partners retire close to each other (Stancanelli and Van Soest, 2012; Michaud et al., 2020).

[14] Based on the data from employer-employee tax filings, we classify an individual as a civil servant if s/he has received an annual working income exceeding 360,000 NTD (which is close to the minimum annuity) from public institutions for over 7 years.

We then divide the retiree household sample into two groups: households whose breadwinner retired as a civil servant (the treatment group) and those whose breadwinner did not (the control group).

Our data compiled as discussed earlier lead to a comprehensive panel dataset comprising asset allocation, income, and various characteristics of households in Taiwan spanning the years from 2013 to 2021. We construct the following variables for each household (the detailed definitions of all variables are provided in Table A2 in the Appendix). *Husband Age* denotes the age of the husband in the household; *Wife Age* denotes the age of the wife in the household; *Male Breadwinner* is an indicator variable that equals one if the primary income earner of the household is the husband and zero otherwise; *Unretire* is an indicator variable that equals one if the retired breadwinner receives annual labor income exceeding 100,000 NTD (which suggests that s/he has returned to the labor market) and zero otherwise; *Child Dependency* denotes the number of children below 24 years old in the household; *Deposits* denotes the amount of household-level bank deposits; *Bond* denotes the amount of bond holdings of the household; *Stock Holdings* denotes the amount of stock holdings of the household; *I_stock* is an indicator variable that equals one if the household holds any stocks in a year and zero otherwise; *Present Value of Cars* denotes the present value of cars of the household; *Assessed Value of Real Estate* denotes the assessed value of houses and land minus the outstanding mortgages of the household; *Owning Real Estate* is an indicator variable that equals one if the household holds any real estate in a year and zero otherwise; *Mortgage* denotes the outstanding mortgages of the household; *Total Wealth* denotes the total wealth of the household; *Deposits/Wealth* denotes the deposits-to-wealth ratio; [15] *Stock/Wealth* denotes the stock-to-wealth ratio; α_m denotes the weighted average of the household stock portfolio's alpha under asset pricing model m; β_m^k denotes the weighted average of the household stock portfolio's exposure to factor k under asset pricing model m; and $\sum\widehat{\epsilon^2}_m$ denotes the weighted average of the household stock portfolio's idiosyncratic risk under asset pricing model m.

Table 1 presents the summary statistics of our full retiree sample before the pension reform, as well as the summary statistics for the treated and the control groups. We acknowledge that the

[15] In general, we extrapolate the amount of the deposits using the average deposit interest rate in Taiwan. However, since civil servants were offered an opportunity to save with an 18% interest rate in a preferential deposit account, we extrapolate their maximum interest income by the preferential interest rate so as not to overestimate their deposits.

summary statistics of the two groups are statistically different – a common feature for population-level data with a large number of observations. We choose to use the full sample in our main analyses for data completeness and transparency; nevertheless, in a later robustness check, we also construct a matched sample in which treated and control households are more homogenous in almost all outcome variables used in our regressions before the reform.

In Table 1, we find that civil servant households tend to hold more deposits but fewer risky assets relative to households with retirees from the private sector. Specifically, the deposits-to-wealth ratio and the stock-to-wealth ratio of civil servant households are 20.8% and 8.0%, respectively, whereas those of their private sector counterparts are 16.3% and 12.1%. On the other hand, bond holding is very limited in all samples.

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 to the pension reform relative to others:

$$AssetAllocation_{it} = bCivilServant_i \times Post_t + X_{it}\Gamma + \mu_i + \delta_t \; or \; \sigma_{ct} + \epsilon_{it}, \qquad (1)$$

where $AssetAllocation_{it}$ denotes variables reflecting the asset allocation decision of household i in year t; $CivilServant_i$ is a binary variable, indicating whether the breadwinner of the household i was a civil servant before s/he retired; $Post_t$ is a time indicator which takes the value of one for the period since the pension reform (i.e., $t \geq 2017$) and zero otherwise. Our primary interest lies in the coefficient b, which captures whether treated households change their asset allocation more than control households do after the pension reform.

X_{it} is a set of control variables that include *Child Dependency* (the number of children under 24 years old) and *ln(1+mortgage)* (the logarithm of outstanding mortgages) that reflect the household's financial burden, and fixed effects for the husband's age to capture the life cycles of households. Moreover, we control for an extensive list of fixed effects, including μ_i for household fixed effects, δ_t for year fixed effects, and σ_{ct} for city-year joint fixed effects. Lastly, ϵ_{it} represents the estimation error. We cluster the standard errors by household as estimation errors are likely to be correlated within each household.

It is worth noting that we do not intend to include too many control variables because almost all economic decisions are influenced by the pension reform. Thus, we should refrain from including those affected variables in our difference-in-differences regression analyses to avoid the "bad control" issue (Angrist and Pischke, 2009; Roberts and Whited, 2013).

As we control for household fixed effects, any time-invariant family-level unobservable characteristics such as the absolute risk aversion and culture, which might simultaneously affect household financial decisions, will be accounted for. The inclusion of year fixed effects absorbs all time-varying aggregate factors, such as business cycles or financial crises. Finally, the city-year joint fixed effects absorb all local economic, regulatory, and policy-related issues.

4.2 Stock holdings

Columns (1) to (3) of Tables 2 and 3 present the estimation results of Equation (1) when we consider two measures for risky asset allocation as the dependent variables: the stock-to-wealth ratio in logarithms (*ln(Stock/Wealth)*) and the total value of stock holdings in logarithms (*ln(Stock Holdings)*).[16] These two variables reflect the riskiness of retirees' asset portfolios, in terms of the relative amount and the absolute amount to total wealth, respectively, following prior literature on household economics and finance. In addition, bonds are much less popular among households in Taiwan, as shown in Table 1.

In Table 2 for the stock-to-wealth ratio, we find that, relative to other retirees, retired civil servants significantly increase their stock-to-wealth ratio after the pension reform. In Column (1), we only include our difference-in-differences term, $CivilServant_i \times Post_t$ as well as household and year fixed effects. The estimated coefficient of $CivilServant_i \times Post_t$ is 0.106, suggesting that, relative to other retirees, retired civil servants significantly increase their stock-to-wealth ratio by 10.6%.

In Column (2), we add more control variables including the number of children under 24 years old, outstanding mortgages, and husband age fixed effects to the regression. We find that the estimated coefficient of $CivilServant_i \times Post_t$ slightly decreases to 0.104, which suggests that our difference-in-differences estimation is robust to our control variables accounting for financial

[16] These two measures reflect the intensive margin of stock market participation (Addoum, 2017; Zhang, 2021). We focus on a sample of households that had held stocks prior to the pension reform in order to leave out the extensive margin, which will be analyzed in our later analyses.

burdens and household life cycles. In Column (3), we replace year fixed effects with city-year joint fixed effects to control for all time-varying local factors. The estimated coefficient of $CivilServant_i \times Post_t$ is 0.102, which suggests that our difference-in-differences estimation is not sensitive to local factors. These three columns collectively suggest that, relative to other retirees, retired civil servants significantly increase the weight of stocks by more than 10% after the pension reform.

In addition, we find significantly positive coefficients for mortgages, which can be attributed to two possibilities. First, given the low mortgage rate in Taiwan, households may choose to invest in stocks instead of paying off their mortgages. Second, richer families can afford to purchase more expensive apartments (with mortgages) and invest more in stocks at the same time.

We then present estimation results for Equation (1) using the total value of stock holdings in Table 3. The structure of Table 3 is the same as that of Table 2, and so we do not include any control variables in Column (1), but add all control variables in Column (2), and introduce city-year joint fixed effects in Column (3). All of these results suggest that, relative to other retirees, retired civil servants significantly increase their stock holdings by 7.6%. Such an estimate is equivalent to 125,000 NTD (about 4,000 USD) given that an average treated household holds stocks worth 1.6 million NTD (about 51,000 USD) prior to the reform as shown in the row labeled Conditional Stock Holdings (thousands) in Table 1. Table 3 not only confirms our results in Table 2 based on the stock-to-wealth ratio, but also points to a significant increase in treated households' investment in equity markets.

One potential concern is that our treated group's increased stock holdings may be driven by stock market conditions. It is noteworthy that the TAIEX index was relatively stable during 2013 to 2019 but experienced a significant increase between 2020 and 2021. However, the fact that retired civil servants increased their stock holdings in 2017 to 2019 suggests that our results cannot be attributed to stock market fluctuations. More discussions will be provided in Section 4.6.

4.3 Parallel trend assumption and potential pre-trend

The identification of our difference-in-differences approach lies in the parallel trends assumption: in the absence of the pension reform, civil servants and their private sector counterparts would have exhibited similar trends in their asset allocation. Although the assumption

is not directly testable, we re-estimate Equation (1) by replacing the variable $Post_t$ with several relative time indicator variables ($I[t-2017=j], j=-4 \cdots 4, j \neq -1$) as follows:

$$AssetAllocation_{it} = \sum_{j=-4, j\neq -1}^{j=4} b_j CivilServant_i \times I\,[t-2017=j] + X_{it}\Gamma + \mu_i + \delta_t \; or \; \sigma_{ct} + \epsilon_{it,} \quad (2)$$

where $I[t-2017=j]$ is a set of relative time indicator variables. $I[0]$ = 1 for all household-year observations in 2017, and zero otherwise. Following the same logic, $I[j]$ = 1 for all household-year observations in $2017+j$, and zero otherwise. We use 2016 as the base year; thus, $I[-1]$ is not included. Our primary interest lies in the sequence of $\{b_j\}_{j=-4}^{j=4}$, which estimates the differences in outcome between the treated and control groups relative to the base year 2016.

Columns (4) and (5) of Tables 2 and 3 report the estimation results of Equation (2) for the stock-to-wealth ratio and the stock holdings, respectively. These results are visualized in Figure 1, which provides the graphical illustration of $\{b_j\}_{j=-4}^{j=4}$ of Column (4) in each table: Panel (a) is for Table 2 (the stock-to-wealth ratio), and Panel (b) is for Table 3 (stock holdings). As presented in Figure 1, we do not find statistically significant b_j before the treatment period, suggesting that there is no difference between the treated and control groups prior to the reform. These results confirm that there is no evidence of differential pre-trends and thus offers supportive evidence to a causal interpretation of our baseline results.

On the other hand, Figure 1 reveals a swift and substantial change in asset allocation following the pension reform. As soon as the reform was determined (2017, j = 0), but prior to the actual cut in the pension (2018, j = 1), the affected households raised their stock-to-wealth ratio and stock holdings. More importantly, retired civil servants kept raising their stock holdings because their income replacement ratio is decreasing by 1.5% annually. Four years after the reform (2021, j = 4), retired civil servants increased their stock-to-wealth ratio by 16.3% and stock holdings by 17.9%, suggesting that an average treated household increased stocks by 294,000 NTD (about 9,500 USD) after the reform. The magnitude of these increases is much higher than the difference-in-differences estimates in Columns (1) to (3) in Tables 2 and 3.

We acknowledge the potential power issue of our pre-trend test, and therefore conduct a robustness test proposed by Roth (2022). The results of the test are presented in Figure 2, where

Panel (a) is for the stock-to-wealth ratio and Panel (b) is for stock holdings. First, we hypothesize a linear violation of the parallel trend. To achieve 80% (50%) statistical power to detect this, the linear pre-trend would need to have a small positive slope of 0.015 (0.01) for both of our main dependent variables (*ln(Stock/Wealth)* and *ln(Stock Holdings)*). If such a pre-trend were present, it would introduce a bias of 0.075 (0.05) four years after the pension reform (illustrated by the red line). However, these potential biases are significantly smaller than our actual estimates for *Civil Servant* × $I[t - 2017 = j]$.

In line with the expected trend, the test also provides the expected values of the coefficients conditional on passing the pre-test under the hypothesized trend (as depicted by the blue dashed line). The graphical analysis suggests that the hypothesis of an undetected pre-trend due to low power is unlikely, as the estimated coefficients from our model exhibit a different pattern compared to those estimated conditionally on passing the hypothesized pre-trend.

4.4 Matched sample

We acknowledge that the different characteristics between retired civil servants and other retirees in our full sample, and are aware of the potential issue that such differences may be driving our difference-in-differences results. In other words, other retirees may not be the best counterfactual for retired civil servants in the absence of the pension reform. To address this concern, we construct a matched sample by matching each retired civil servant family with their three nearest private sector counterparts using the Mahalanobis distance. This matching is based on the following observable characteristics in 2016, the year right before the pension reform: *Husband Age, Wife Age, Male Breadwinner, Unretire, Child Dependency, ln(1+Deposits), ln(1+Stock Holdings), ln(1+Total Wealth), Deposits/Wealth, Stock/Wealth,* α_{CAPM}, β_{CAPM}^{MKT}, and $\sum \widehat{\epsilon^2}_{CAPM}$. The three matched nearest neighbors of each retired civil servant family are then included as the matched control group in the matched sample.

Table 4 provides the summary statistics of the matched sample. Column (1) shows the sample mean of the treated group, Column (2) shows the sample mean of the matched control group, and Column (3) presents the results of a two-sample t-test of the null hypothesis that the two groups are the same in each characteristic. We find almost no statistical difference in asset allocations between the treatment group and the matched control group. Specifically, the two groups are reasonably homogenous in the total wealth (15,142 vs. 15,476), the incidence of stock

holding (0.68 vs. 0.69), the stock-to-wealth ratio (0.08 vs. 0.08), the deposits-to-wealth ratio (0.20 vs. 0.20), portfolio characteristics (α_{CAPM}, β_{CAPM}^{MKT}, α_{FF3}, β_{FF3}^{MKT}, β_{FF3}^{SMB}, β_{FF3}^{HML}, α_{FF5}, β_{FF5}^{MKT}, β_{FF5}^{SMB}, β_{FF5}^{HML}, β_{FF5}^{RMW}, and β_{FF5}^{CMA}), proportion of gains realized (0.17 vs. 0.17), and proportion of losses realized (0.10 vs. 0.10). We also find that, although the two groups appear significantly different in other demographic characteristics, those differences in mean are relatively small in economic magnitude.

We then estimate Equation (2) using the matched sample and present the results in Table 5 and Figure 3. Again, we find no violation of the pre-trend test in Figure. The estimates are similar to the results from our full sample, indicating that civil servants increased their stock-to-wealth ratios and stock holdings by 13% and 16%, respectively, four years after the reform. The fact that we find similar estimates using either the matched sample or the full sample suggests that the parallel trend assumption generally holds regardless of the initial differences in asset allocation.

4.5 Stock-level riskiness

To verify that the increase of retired civil servants' stock holdings indeed reflects their choice for riskier assets, we investigate the risk profiles of stocks they hold by constructing model-based measures for stock riskiness. Specifically, we evaluate the riskiness of stocks and portfolios using three common asset pricing models: Capital Asset Pricing Model (henceforth CAPM), the Fama-French three-factor model (henceforth FF3; Fama and French, 1993), and the Fama-French five-factor model (henceforth FF5; Fama and French, 2015).

We estimate the alpha, betas, and idiosyncratic risk for each stock each year by applying rolling regressions over the past 36 months of monthly return data. Specifically, for each month, we estimate the following equations using a 36-month window ending in that month:

$$r_{s,t} - r_{f,t} = \alpha + \beta_{CAPM}^{MKT}\left(r_{m,t} - r_{f,t}\right) + \epsilon_t, \tag{3}$$

$$r_{s,t} - r_{f,t} = \alpha + \beta_{FF3}^{MKT}\left(r_{m,t} - r_{f,t}\right) + \beta_{FF3}^{SMB} \cdot \mathrm{SMB}_t + \beta_{FF3}^{HML} \cdot \mathrm{HML}_t + \epsilon_t, \tag{4}$$

$$r_{s,t} - r_{f,t} = \alpha + \beta_{FF5}^{MKT}\left(r_{m,t} - r_{f,t}\right) + \beta_{FF5}^{SMB} \cdot \mathrm{SMB}_t + \beta_{FF5}^{HML} \cdot \mathrm{HML}_t + \beta_{FF5}^{RMW} \cdot \mathrm{RMW}_t + \beta_{FF5}^{CMA} \cdot \mathrm{CMA}_t + \epsilon_t, \tag{5}$$

where $r_{s,t}$ is the monthly return of stock *s* in month *t*; $r_{f,t}$ is the risk-free rate; $r_{m,t}$ is the monthly return of the market portfolio (approximated by the TAIEX index); SMB is the size factor; HML

is the value factor; RMW is the profitability factor; CMA is the investment factor; and ϵ_t represents the estimation error[17].

We repeat this rolling window estimation in each month and then take the average of the monthly estimates within each calendar year to obtain stock-year-level estimates of alphas, betas, and idiosyncratic risk.

Next, we measure household-level portfolio risk exposure as follows. For each household in year *t*, we define its portfolio alpha α_m, factor loadings β_m^k, and idiosyncratic volatilities $\sum \widehat{\epsilon_m}^2$ as the weighted average of its stocks' alphas, betas, and idiosyncratic volatilities estimated in year *t-1* weighted by the value of stocks it holds in year *t*, respectively. The subscript $m \in$ {CAPM, FF3, FF5} denotes the factor model used, and the superscript *k* denotes the associated factors (e.g., market factor, size factor, value factor, profitability factor, and investment factor). We construct portfolios-level risk exposure measures using lagged stock risk exposures because households' asset allocation decisions in year *t* are based on their available information.

We then estimate Equation (1) with the model-based, portfolio risk measures constructed above as dependent variables. The results based on CAPM are reported in Table 6. We include all the control variables throughout Column (1) to Column (6). Column (1) to Column (3) report the conventional two-way fixed effects estimates, whereas Column (4) to Column (6) replace year fixed effects with city-year joint fixed effects to account for all time-varying local factors.

For α_{CAPM}, the coefficients of $CivilServant_i \times Post_t$ are always positive and statistically significant at the 1% level: the coefficients in Column (1) and Column (4) are 0.041 and 0.038, respectively. These results tentatively suggest that retired civil servants' switch to the stocks that had generated higher returns in prior years; nevertheless, this pattern will be further examined using the FF3 and FF5 models.

For β_{CAPM}^{MKT}, the estimated coefficients of $CivilServant_i \times Post_t$ are 0.0032 and 0.0034 in Column (2) and Column (5), respectively, which are both statistically significant at the 1% level. These results suggest that, relative to the control households, the treated households' average

[17] To ensure sufficient data for precise estimation, we restrict our stock sample to those with at least 36 months of return history. In other words, newly listed (IPO) stock with less than three years of data are excluded from the analysis.

market beta increases by around 15%. The increase in the high-beta stock holdings of retired civil servants supports our proposition: these treated retirees invested more in risky assets.

We also note the significant negative coefficient for *Child Dependency*, which is about -0.001 throughout Columns (2) and (5). The estimates suggest that each child below 24 years old causes the average portfolio's market beta to decrease by 2.5%: when households are responsible for raising their kids, they seem to take on less systematic risk. The coefficient for residential mortgages, on the other hand, is insignificant.

For $\sum\widehat{\epsilon^2}_{CAPM}$, the estimated coefficients of $CivilServant_i \times Post_t$ in Columns (3) and (6) are 269.59 and 288.04, respectively, which are both statistically significant at the 10% level. These estimates provide suggestive evidence for an increase in unexplained risk or the deviations from mean-variance optimization among treated retirees. There are two explanations for such an increase: first, if the idiosyncratic volatility/risk is related to higher expected stock returns (Merton, 1987; Fu, 2009), retired civil servants may pursue stocks with high idiosyncratic risk to offset their annuity cuts. Second, if idiosyncratic volatility reflects unexplained risk that does not bring risk premiums, our result may be attributed to retired civil servants' irrational investment under intensified financial pressure from the pension reform. They are likely to trade stocks more frequently or be more easily distracted by rumors,[18] thereby deviating from the optimal mean-variance portfolios. This also suggests that financial constraints may force households to deviate from optimal financial decisions.

The results based on FF3 are presented in Table 7. All the control variables are included in Column (1) to Column (5). Panel A reports the conventional two-way fixed effects estimates, while Panel B replaces year fixed effects with city-year fixed effects to absorb local variation.

First, after controlling for size and value premia, the coefficients on $CivilServant_i \times Post_t$ for α_{FF3} become statistically insignificant. This suggests that the previously observed abnormal return in CAPM can, in fact, be explained by exposure to the size and value risk exposures.

Second, the coefficients of $CivilServant_i \times Post_t$ on β_{FF3}^{MKT} are 0.0031 and 0.0033 in Panels A and B, respectively. These estimates imply an increase in average market beta of approximately 13%, which is consistent with the results based on CAPM. The coefficients of *Child*

[18] Barber, Lee, Liu, and Odean (2009) show that stock investors in Taiwan suffer from frequent trading.

Dependency are -0.0005 and -0.0004 in these two panels and statistically significant at the 1% level, while the effect residential mortgage is statistically insignificant.

We also observe the positive coefficients on β_{FF3}^{SMB} and β_{FF3}^{HML} are 0.002 and 0.006-0.007, respectively. These estimates suggest that, following the pension reform, retired civil servants shifted their stock portfolios toward smaller and value-oriented firms compared to their private sector counterparts.

Lastly, the increase in idiosyncratic risk is much smaller in magnitude (compared to CAPM) but remains statistically significant at the 10% level. This indicates that the observed deviation from mean-variance optimization may be largely explained by the increased exposure to the size and value risk.

The results based on FF5 are presented in Table 8. The structure of Table 8 mirrors that of Table 7. The coefficients of $CivilServant_i \times Post_t$ for β_{FF5}^{MKT} and β_{FF5}^{SMB} remain similar to the results reported in Table 7 under the FF3 specification. However, we observe a slight decline on the difference-in-differences estimate for β_{FF5}^{HML}, accompanied by a positive and statistically effect on β_{FF5}^{RMW}. In contrast, the estimates for β_{FF5}^{CMA} is statistically insignificant. These findings suggest that retired civil servants also increased the exposure to profitability risk.

Compared to the FF3 results, the coefficient on $CivilServant_i \times Post_t$ for $\widehat{\sum \epsilon^2}_{FF5}$ becomes statistically insignificant, indicating that the increased risk profile of retired civil servants' portfolios can be *fully* explained by their higher exposure to four risk factors: market, size, value, and profitability.

Taken together, our results based on model-based risk measures consistently suggest that retired civil servants increased their exposures to four factors—market, size, value, and profitability—following the pension reform. Across all three models (CAPM, FF3, and FF5), the estimated increase in market beta ranges from 13% to 15% relative to their private sector counterparts. Treated households also increased their exposure to systematic risk related to size, value, and profitability.

4.6 Our results and prospect theory

Under a standard expected utility framework with either constant or decreasing relative risk aversion, a large and permanent reduction in pension income should lead a decrease in risky assets

holdings,[19] either in levels or as a share of wealth, as households shift away from risky assets to stabilize consumption in the face of reduced lifetime resources. This prediction, however, is not supported by our data.

Our findings are more consistent with the predictions of prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992), which emphasizes that individuals evaluate outcomes relative to a reference point and exhibit asymmetric risk preferences around it—being risk-averse in the domain of gains and risk-seeking in the domain of losses. In our context, the pre-reform annuity, which civil servants had long expected to receive throughout life time, serves as a salient reference point. The abrupt and retroactive pension reform thus creates a perceived loss relative to this reference, even if absolute consumption levels remain adequate.

Kőszegi and Rabin (2006, 2007, 2009) propose that reference points are shaped by recent expectations and prior entitlements, and formalize the reference-dependent preferences based on consumption. The history dependent pattern of reference points is supported by recent empirical studies (Simonsohn and Loewenstein, 2006; Bordalo, Gennaioli, and Shleifer, 2018; DellaVigna et al., 2017; Lian, Ma, and Wang, 2019). We argue that civil servants perceived annuity cuts as a direct loss relative to their anticipated retirement trajectory. In response, many of them increased their exposure to risky assets for higher expected returns, consistent with prospect theory's prediction of risk-seeking behavior in the loss domain. Put differently, after the reform, retired civil servants faced a choice between maintaining the status quo—keeping their current level of savings in low-risk assets while absorbing the full impact of annuity cuts—or rebalancing their portfolios toward riskier assets in the hope to cover some of the perceived losses. From the perspective of prospect theory, the former choice is to accept a sure loss, while the latter offers a chance to "break even," making the riskier stocks more psychologically appealing despite its higher variance.

It is noteworthy that the risk-seeking in the loss domain has been robustly demonstrated in experiments (Abdellaoui et al., 2008; Harbaugh et al., 2010; Barberis, 2013; Lian, Ma, and Wang, 2019), there is limited evidence in real-world scenarios. Experimental studies often involve smaller

[19] Recent empirical studies find that households' relative risk aversion is either constant or decreasing in wealth (for evidence of constant relative risk aversion (CRRA), see Brunnermeier and Nagel, 2008; Chiappori and Paiella, 2011; Sahm, 2012; for evidence of decreasing relative risk aversion (DRRA), see Guiso and Paiella, 2008; Calvet and Sodini, 2014). Levy (1994) rejects the possibility of increasing relative risk aversion (IRRA) based on an experiment.

stakes than those found in real-life situations, the samples of experimental setting are often not representative, and inducing real wealth loss in an experimental setting is inherently difficult (Levitt and List, 2007; Harrison and Rutström, 2008; Wakker, 2010). Page, Savage, and Torgler (2014) could be the first to offer real-world evidence, but their study involved much smaller stakes (choosing between $10 AUD and a lottery scratch card worth $10 AUD) and a much smaller sample size (220 surveyed individuals) compared to the present study.

Our study thus offers novel quasi-experimental evidence on how households adjust risk exposure in response to substantial and permanent wealth losses—providing a rare real-world validation of prospect theory's predictions at scale.

4.7 Disposition Effect

A key behavioral bias associated with prospect theory is the disposition effect, which refers to investors' tendency 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).[20] The underlying intuition is that investors treat the purchase price as a natural reference point. When a stock's price falls below this reference, investors perceive it as a loss and become risk-seeking in the loss domain, choosing to hold the losing stock in hopes of a rebound. Conversely, when the price rises above the reference point, they are more likely to realize the gains prematurely by selling the stock.

We now examine whether the disposition effect becomes more pronounced when households are subject to annuity cuts in Taiwan. To test this hypothesis, we calculate households' year-over-year changes in stock shares held and corresponding stock prices. This allows us to identify the paper gains, paper losses, realized gains, and realized losses.[21] Building on Odean (1998), we construct two key measures: the *Proportion of Gains Realized* (PGR) and the *Proportion of Losses Realized* (PLR).[22] The PGR is defined as the ratio of realized gains to the sum of realized and paper gains, while the PLR is the ratio of realized losses to the sum of realized and paper losses.

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

[21] We acknowledge that, due to data limitations, we cannot observe transactions that occur between two yearly tax filings. Therefore, the indexes constructed here should be interpreted as reflecting transactions associated with long-term stock holdings.

[22] Odean (1998) defines the two ratios based on the number of stocks sold versus those held. In contrast, we construct the ratios using the value of stocks realized and the value of paper gains or losses, as investors may not fully liquidate a stock in a single transaction or a single year, and each share carries a different weight in the portfolio.

Table 9 reports the estimation results of Equation (1), where Panel A uses the natural logarithm of one plus *Realized Gains*, and Panel B uses the natural logarithm of one plus *Realized Losses* as the dependent variable. Column (1) reports the standard two-way fixed effects estimates without additional controls. Column (2) further includes *Child Dependency* and residential mortgage as covariates, and Column (3) replaces year fixed effects with city-year fixed effects to account for the time-varying local factors.

After controlling for the number of children under age 24, the estimated coefficients on the interaction term $CivilServant_i \times Post_t$ are approximately 0.275 for *ln(1 + Realized Gains)* and 0.135 for *ln(1 + Realized Losses)*, and are not sensitive to the inclusion of local economic controls. Prior to the pension reform, the average annual realized gains and losses for retired civil servants were NT$46,700 and NT$24,000, respectively. A back-of-envelope calculation suggests that the gap between realized gains and realized losses widened by approximately 42% following the pension cut.[23] To formally test whether the effects differ across gains and losses, we conduct a Wald test after separately estimating Column (3) for both outcomes. The test confirms that the differential effect of pension reform on realized gains versus losses is statistically significant at the 1% level.

Table 10 reports the results from estimating Equation (1) using the *Proportion of Gains Realized* (PGR) as the dependent variable in Panel A and the *Proportion of Losses Realized* (PLR) in Panel B. The table structure mirrors that of Table 9. The estimated coefficients on $CivilServant_i \times Post_t$ are 0.013 for PGR and 0.006 for PLR, corresponding to increases of approximately 6.8% and 4.4%, respectively. The Wald test again confirms that these effects are statistically different at the 1% level.

Taken together, these two sets of results provide robust evidence of an amplified disposition effect in a comprehensive sample of household portfolios. When retired civil servants face financial constraints and rebalance their portfolios in response to the pension reform, they appear to exhibit a stronger tendency to sell winners while holding on to losers—consistent with another behavioral bias predicted by prospect theory.

[23] [46,700×(1+0.275) - 24,000×(1+0.135)]/(46,700 - 24,000) = 1.423

It is worth noting that capital gains on stock investments are not taxed in Taiwan, although dividends and stock interest are subject to income tax. Given this tax structure, a rational investor should prefer realizing capital gains over receiving dividends and should hold on to winning stocks rather than losing ones. Therefore, the disposition effect observed here cannot be attributed to any tax incentives such as high short-term capital gains taxes, tax-loss harvesting, or tax-swap strategies.

4.8 Alternative explanations

In this section, we further discuss an extensive list of alternative explanations for our baseline results. The first set of explanations is related to time constraints, financial literacy, and regulatory restrictions: civil servants may have heavy workloads and thus do not have time to analyze and invest in stocks before they retire. In addition, civil servants may be prohibited from or discouraged from investing in stocks due to conflicts of interest.[24] Moreover, they may consider their pension plan as secured permanent income. All of these will result in their lack of stock investment experience and lower financial literacy, leading to underinvestment in stock markets (Guiso, Haliassos, and Jappelli, 2002; Calvet, Campbell, and Sodini, 2007). However, all these issues existed *before* the reform and thus cannot explain the change in the retirees' stock holdings right after it. Furthermore, a higher ratio of civil servant households held stocks (69.2%) than private sector ones (66.1%) prior to the reform. Moreover, our sample includes only retirees who retire before the pension reform; thus, if they need to hold more stocks after retirement, they should have done so before the event. With all these discussions, we rule out the aforementioned alternative explanations.

Another possible explanation is that civil servants switched from the preferential deposits with an 18% annual interest rate (which was gradually terminated after the reform) to stock holdings. With the removal of the risk-free yet high return from the preferential deposits, civil servants may have opted to switch their preferential deposits to stocks that carry higher expected returns. However, it is important to note that the preferential interest offer was still available at 9% until 2020, which is comparable to expected annual dividend-adjusted stock returns in Taiwan.[25]

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

[25] The preferential interest rate was 18% before July 2018, 9% between July 2018 and December 2020, and no longer available starting from January 2021. Even the 9% in 2020 is still comparable to expected annual dividend-adjusted

In spite of this, we observed persistent increases in stock holdings and the stock-to-wealth ratio in 2017-2020 (Figures 1 and 2). This potential explanation can thus be ruled out.

Another potential explanation is that retired civil servants, for some reasons, decided to hold more stocks than other retirees when the aggregate equity market went up. As discussed earlier, the TAIEX index was relatively stable from 2013 to 2019 and experienced a significant increase between 2020 and 2021. However, we have observed a significant increase in retired civil servants' stock holdings since 2017, as shown in Figures 1 and 3, which is way before 2020. This potential explanation is thus not supported.

4.9 Subgroup analysis based on financial pressure

After documenting the significant portfolio effects in response to the pension reform, we perform a subgroup analysis related to retirees' financial pressure. We find that such an asset re-allocation is more pronounced in households with more children of dependency age (i.e., those under 24 years old). We estimate Equation (1) by dividing the sample into subgroups: households without children of dependency age, those with one child of dependency age, and those with two or more children of dependency age.

Table 11 presents the estimation results: Columns (1) to (3) are for *ln(Stock/Wealth)* and Columns (4) to (6) are for *ln(Stock Holdings)*. Columns (1) and (4) focus on the sample of households without children of dependency age, Columns (2) and (5) focus on the sample of households with one child of dependency age, and Columns (3) and (6) focus on the sample of households with two or more children of dependency age. By comparing those without children of dependency age with those with two or more children of dependency age, the coefficient estimates of $CivilServant_i \times Post_t$ are 0.090 and 0.184 for the stock-to-wealth ratios, and 0.076 and 0.126 for stock-holdings, respectively. In other words, the effects of the pension reform almost double when a household has two or more children to raise.

This finding is consistent with the negative coefficients of *Child Dependency* on market betas in Tables 6 to 8. In other words, households facing greater financial pressure—proxied by the

stock returns (the average annual dividend-adjusted stock return is 9.6% in 2012-2016, and 11.5% in 2012-2019); thus, it is reasonable to assume that retired civil servants would not withdraw their preferential deposits before the end of 2020.

presence of dependent children—tend to invest more in the stock market, yet construct portfolios with lower systematic risk.

5. Additional Analyses

5.1 Stock market participation

In addition to the intensive margin of stock market participation, we also consider the extensive margin of stock market participation. We construct an indicator variable *I_stock* that equals one if a sample household holds any stocks in a specific year and zero otherwise. As shown in Table 1, 69.2% of treated households hold stocks, and 66.1% of control households hold them. This suggests that there was little difference in terms of holding risky assets between civil servant families and their counterparts before the pension reform.[26] We then estimate Equation (1) using *I_stock* as the dependent variable and using all households (regardless of whether they held any stocks before the pension reform or not) in our sample. Our estimation is based on a linear probability model because Probit and Logit model estimates are inconsistent due to the incidental parameter problem under a short panel with a large cross-section (Neyman and Scott, 1948; Wooldridge, 2010; Arellano and Hahn, 2006, page 1).

Table 12 presents the estimation results. Similar to previous tables, we do not include any control variables in Column (1), add all control variables in Column (2), and introduce city-year joint fixed effects in Column (3). The coefficient estimates of $CivilServant_i \times Post_t$ are 0.005, 0.006, and 0.005 in Columns (1) to (3), respectively. All these estimates suggest that in response to the pension reform, the treated households' probability of participating in stock markets increases by approximately 0.5 percentage points. We acknowledge that this magnitude is small, especially in contrast to the large economic impact observed along the intensive margin in Section 4. Nevertheless, this result aligns with the "participation puzzle" (Haliassos and Bertaut, 1995), which describes the phenomenon that individuals do not enter the financial market despite economic theory predicting that they should hold risky assets regardless of their wealth or risk-aversion attitudes (Merton, 1969).

5.2 Deposits and total wealth

[26] We also find that the value of real estate held by treated households is similar to that of control households before the reform; nevertheless, the ratio of owning any real estate is higher among the treated group (94.2% vs. 89.2%).

In addition to prior analyses on risky assets, we also attempt to quantify the effect of the pension reform on bank deposits, which often serve as precautionary savings. We then estimate Equation (1) using the logarithmic form of the variable *Deposits/Wealth* as the dependent variable – we focus on the deposits-to-wealth ratio because deposits are the most popular form of savings in Taiwan – and report the results from three different specifications in Table 13. The three columns indicate that the coefficient estimates for $CivilServant_i \times Post_t$ are -0.223, -0.227, and -0.223, respectively. These results suggest that, relative to the control households, the treated households' deposits-to-wealth ratios decline by 22%.

We find no significant effect of *Child Dependency* (the number of children below 24 years old), but find that residential mortgages contribute to a higher deposits-to-wealth ratio. A 1% increase in mortgages is associated with a 1.5% increase in the deposits-to-wealth ratio, which can be attributed to households' liquidity concerns or the low mortgage rate in Taiwan. Thus, households tend to place their savings in bank deposits instead of paying off mortgages.

Next, we also assess the effect of the pension reform on household wealth by estimating Equation (1) with one plus total wealth in logarithm as the dependent variable. Since the reform directly reduces civil servant retirees' annuities, we expect a decline in household wealth. Table 14 presents our estimation results. In Column (3), which accounts for local economic conditions by incorporating city-year fixed effects, our estimation suggests that the total wealth of civil servant households decreases by 3.67%, equivalent to a decrease of 549.5 thousand NTD, relative to control households after the reform. Moreover, we find significantly negative coefficients of *Child Dependency* and *ln(1+Mortgages)*, which suggest that an additional child below 24 years old leads to a 1.97% reduction in total wealth, and a 1% increase in mortgages is associated with a 2.13% reduction in total wealth.

We acknowledge that the magnitudes of the reductions in deposits and total wealth are substantial, which is consistent with the drastic cut to pension income and confirms the real effect of the pension reform.

5.3 Post-retirement jobs

The stringent financial pressure resulting from the pension cut may motivate civil servant retirees to re-enter the labor force to generate extra earnings, which has implications for the labor supply of senior citizens. In our sample, we construct an indicator variable, *Unretire*, which equals

one if the annual labor income of the retired breadwinner exceeds 100,000 NTD in a year and zero otherwise. This threshold is set to capture an income source that requires substantial labor input from retirees. We estimate Equation (1) using a linear probability model with *Unretire* as the dependent variable. The results are reported in Table 15 which presents our estimates of the employment effects. The coefficients for $CivilServant_i \times Post_t$ in Columns (1) to (3) are 0.046, 0.047, and 0.047, respectively. These estimates suggest that, relative to the control group, the probability of the treated retirees' re-entry into the job market increases by more than 4 percentage points following the reform. The economic magnitude of this coefficient estimate is reasonably substantial given that the average *Unretire* of civil servant retirees is 14% prior to the reform. In other words, if the control group's *Unretire* is fixed, then retired civil servants' *Unretire* increases from 14% to 18%. On the other hand, we note that the average *Unretire* of control retirees is 29% before the reform. Thus, even if our treated retirees are more likely to return to the workplace following the pension cut, their likelihood of doing so is still lower than that of control retirees.

Furthermore, we find that the presence of dependent children under the age of 24 increases the probability of re-entering the workplace, with having one dependent child increasing *Unretire* by 0.63 percentage points. The coefficients for mortgages are insignificant.

Our results in Table 15 not only confirm the real impact of the pension reform on treated households' financial constraints, but also suggest policy implications for senior citizens' labor supply. We note that, after the pension reform, retired civil servants' annuities are suspended if they earn compensation above a certain level under certain conditions, which actually reduces the incentive of these retirees to find another job.[27] Despite such a disincentive, the rate of re-entry of these retirees still increased from 14% to 18%. In other words, if such a restriction is not imposed, we would expect the likelihood of re-entry to increase even more. This finding furthers our understanding of unretirement, in contrast to the prior literature (Maestas, 2010) that suggests that coming out of retirement was often planned and not primarily driven by financial shocks, poor planning, or low wealth accumulation. Instead, we find that re-entering the labor market serves as

[27] The pension reform imposes limitations on rehiring retired civil servants in government positions, government-donated foundations, and government-invested companies. If the retirees' monthly salary for taking up such positions exceeds the basic wage, their annuities will be suspended.

a means for retired civil servants to maintain a certain level of subsistence in response to a significant pension cut.

6. Conclusion

In this paper, we provide novel, population-level evidence for how retirees' asset allocation responds to an unexpected deep cut to annuity. We analyze the impact of the 2017 civil servant pension reform in Taiwan, which retroactively cut the retirement annuities of civil servants from the 75%-95% range to the 30%-62.5% range. Using administrative tax record data covering all Taiwanese households and by designing a difference-in-differences approach, we find substantial increases in the intensity of stock market participation. Specifically, treated households (i.e., those with retired civil servants) increased their stock-to-wealth ratios by over 10%, their stock holdings by over 7%, and portfolio market beta by 13-15%. The reform also amplified treated households' disposition effect. This pattern of asset re-allocation is more likely to occur among households with more young children (which are subject to greater financial pressure). In addition, treated households suffered from reduced deposits and wealth and were more likely to re-enter the labor market.

The increased shareholdings and heightened exposure to systematic risk among retired civil servants suffering from annuity cuts cannot be readily explained by the standard expected utility framework. Instead, these behavioral responses are more consistent with prospect theory of Kahneman and Tversky (1979) and Tversky and Kahneman, (1992). Our evidence based on comprehensive population data complements prior studies based on experiments and surveys that may suffer from limited real impact, smaller sample size, and selection issues.

Moreover, our empirical investigation offers several important policy implications for shareholder protection, stock market regulation, and social welfare, which echoes the call of Gomes, Haliassos, and Ramadorai (2021) with regard to applying empirical results to the design of regulations. First of all, the increased stock investment of retired civil servants may enhance stock market liquidity and depth; however, these retail investors are subject to greater financial constraints and may thus trade more irrationally or too frequently. Second, given the aging of the population, the increase in the labor supply of civil servant retirees may be re-directed to other sectors of the economy to enhance social welfare. Third, while annuity cuts enhance the

sustainability of pension systems and ease governments' financial burdens,[28] they also discourage talented young people from becoming civil servants, which may negatively impact the creativity and efficiency of governments in the long run. Finally, the annuity cuts have also introduced uncertainty into people's perceptions of government-backed pension plans, potentially reducing their incentive to continue to contribute to these plans. Such reduced incentives may lead to a decrease in short-term cash inflows into these plans and eventually hurt their sustainability.

[28] Moreover, prior studies also raise concerns on pension fund management and governance, which exacerbate the pension deficits in the U.S. (Andonov, Bauer, and Cremers, 2017; Andonov, Hochberg, and Rauh, 2018).

Appendix

A.1 The civil servants' pension system before the reform

The salary calculation within Taiwan's civil service operates within a points-based framework, where distinct ranks and levels are allocated 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 the associated salary points.

ii. Professional Allowance: Offered to civil servants with specialized skills, qualifications, or expertise relevant to their roles. It serves as an 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 fusion of these four components, namely, base salary, professional allowance, position allowance, and remote area allowance, constitutes the comprehensive monthly income of a civil servant in Taiwan. Typically, the base salary constitutes approximately half of the total monthly salary, 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 involves a two-step process. First, the monthly pension and income replacement ratio are determined based on the duration of service. Secondly, civil servants are provided the opportunity to save in a preferential deposit account with an 18% annual interest rate. There are two distinct formulas used to determine the income replacement ratio:

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

where individuals with tenure of less than 25 years are assigned 25 years, and tenure is capped at 35 years.

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

where individuals with tenure of less than 15 years are assigned 15 years, and tenure is capped at 30 years. The base salary is determined based on the individual's final salary prior to retirement.

Based on these formulas, the civil servant's pension is determined by the plan offering the lower preferential interest. Typically, Formula A is designed for higher-ranked officers, while Formula B caters to elementary civil servants. Irrespective of the two formulas employed, it is evident that civil servants are guaranteed a minimum of approximately 75% of their monthly

income while actively working, with the potential to reach up to 95% (as shown in the top row of Table A1).

Table A1: Income Replacement Ratio Before and After the Pension Reform

Tenure	40	35	30	25	20	15
Income Replacement Ratio of (A)	95%	95%	85%	75%	75%	75%
Income Replacement Ratio of (B)	90%	90%	90%	85%	80%	75%
Income Replacement Ratio in 2029	62.5%	60%	52.5%	45%	37.5%	30%

A.2 Pension reform in relation to civil servants in 2017

The "Civil Servants Retirement, Severance, and Dismissal Compensation Act" was passed by the Legislative Yuan (which is analogous to the two chambers in the U.S.) on June 27, 2017, following its third reading. This pivotal 2017 pension reform has served as a substantial policy initiative, aiming to improve financial sustainability within the pension systems for military personnel and civil servants. Key components of the reform include the following:

- Increasing the Normal Retirement Age: The reform raised the normal retirement age for civil servants, ensuring that they retire later than before.
- 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 as it contributed to the financial imbalance in the system.[29]
- Restriction on Reappointment: Retired civil servants are limited when it comes to seeking reappointment in government positions, government-donated foundations, and government-invested companies. If their monthly salary in these subsequent roles surpasses the legally-defined basic wage, their pension will be suspended.
- 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. With the abolition of the 18% preferential interest rate, the formula for the income replacement ratio was modified as follows:

[29] 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.

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

In the updated formula, individuals with tenure of less than 15 years are assigned 15 years, and tenure is capped at 40 years. The "average base salary," initially calculated as the average base salary of the last five years at work starting from June 2018, is being gradually extended to the average base salary of the last 15 years of work by 2029.

Moreover, a significant reduction in the income replacement ratio occurred in June 2018, with the decrease in the rate fixed at 1.5% annually from 2020 to 2029. In 2029, the income replacement ratio will be reduced to a range between 30% and 62.5% (as presented in the bottom row of Table A1). However, there is an exception: to guarantee a certain standard of living, in that individuals whose monthly pension falls below 33,140 NTD after the reform will receive a minimum of 33,140 NTD.

Table A2: 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 was the husband and 0 otherwise.
Unretire	Takes a value of 1 if the retired breadwinner receives annual labor income exceeding 100,000 and 0 otherwise.
Child Dependency	The number of children below 24 years old in the household.
Deposits	The amount of bank deposits of the household, which is extrapolated by taxable interest income, using the market saving interest rate in general. We extrapolated the preferential deposits of civil servants using the preferential interest rate offered.
Bond	The amount of bond holdings, which is extrapolated by taxable interest income.
Stock Holdings	The amount of stock holdings of the household. 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.
I_stock	Takes a value of 1 if the household holds any stocks and 0 otherwise.
Present Value of Cars	The present value of cars approximated by the documented engine size and brand.
Assessed Value of Real Estate	The value of housing and land values based on government assessments minus the estimated outstanding mortgages.
Owning Real Estate	Takes a value of 1 if the household holds any real estate and 0 otherwise.

Mortgage	The outstanding mortgages of the household. We distribute the aggregate mortgage amount proportionally to each household based on their share of the household mortgage interest within the aggregate mortgage interest.
Total Wealth	The total wealth of the household, calculated as the sum of Deposits, Bond, Stock Holdings, Present Value of Cars, and Assessed Value of Real Estate.
Deposits/Wealth	The deposits-to-wealth ratio, calculated as Deposits divided by Total Wealth.
Stock/Wealth	The stock-to-wealth ratio, calculated as Stock Holdings divided by Total Wealth.
Civil Servant	Takes a value of one if s/he has received an annual working income exceeding 360,000 NTD from public institutions for over 7 years and zero otherwise.
Post	A time indicator which takes the value of 1 for the period since 2017 and 0 otherwise.
$\boldsymbol{\alpha_m}$	The weighted average of the household stock portfolio's α (intercept term) estimated under asset pricing model *m*, based on the past 36 months of returns in the previous year. The model *m* includes CAPM, the Fama-French three-factor model, and the Fama-French five-factor model.
$\boldsymbol{\beta_m^k}$	The weighted average of the household stock portfolio's β^k under asset pricing model *m*, where factor k includes the market premium, size premium, book-to-market premium, earnings premium, and investment premium. The models m include CAPM, the Fama-French 3 factors model, and the Fama-French 5 factors model.
$\sum \widehat{\epsilon_m}^2$	The weighted average of the household stock portfolio's idiosyncratic risk, measured as the sum of squared residuals from asset pricing model *m*, based on the past 36 months of returns in the previous year. The models m include CAPM, the Fama-French 3 factors model, and the Fama-French 5 factors model.
Realized Gains	The monetary value of gains realized, identified through year-over-year changes in stock holdings and corresponding stock prices.
Realized Losses	The monetary of losses realized, identified through year-over-year changes in stock holdings and corresponding stock prices.
Paper Gains	The unrealized gains calculated based on year-over-year changes in stock holdings and corresponding stock prices.
Paper Losses	The unrealized losses 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.
I[t-2017=j]	The relative time indicator, which takes a value of 1 if the observation year is 2017+j and 0 otherwise.

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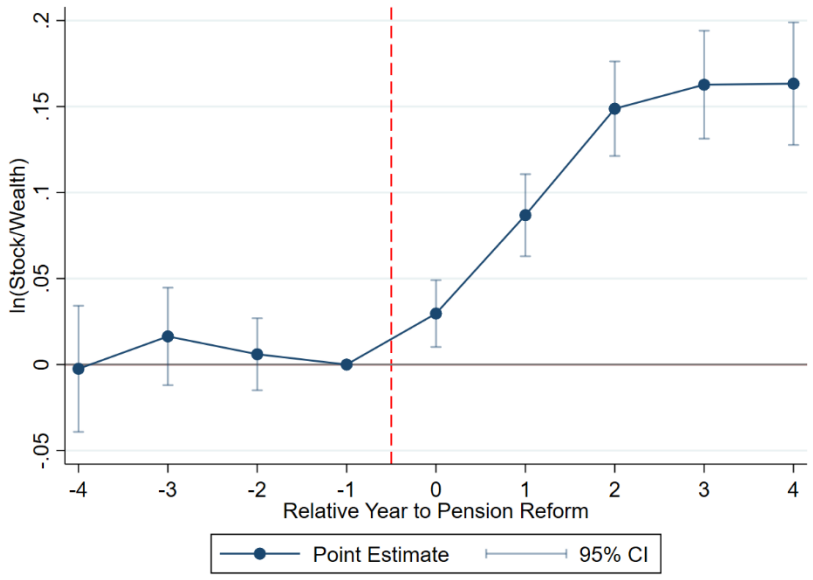
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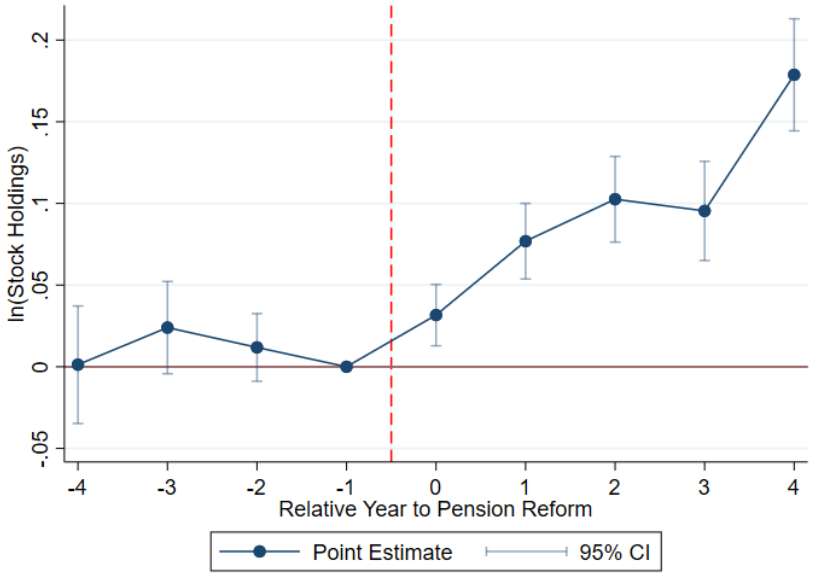
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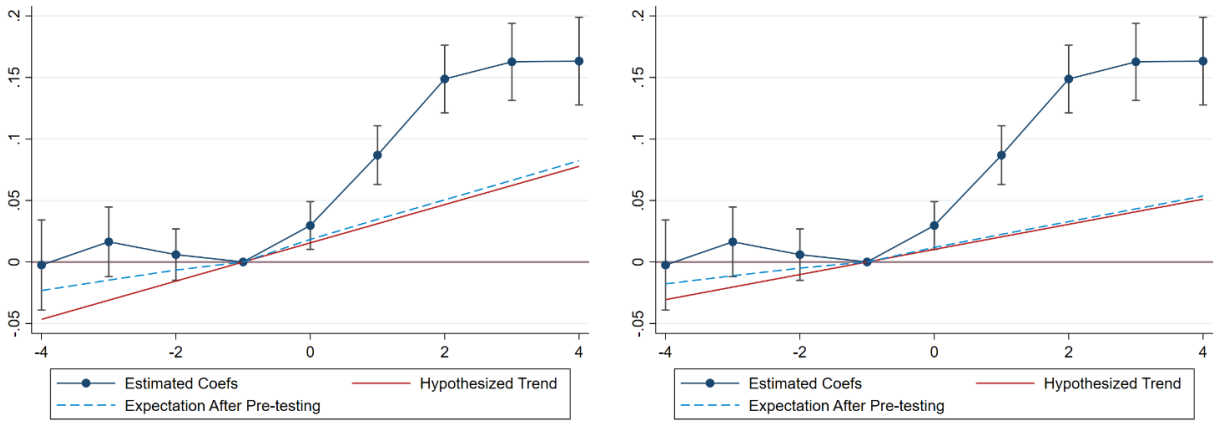
(a) Logarithm of stock-to-wealth ratio in different years



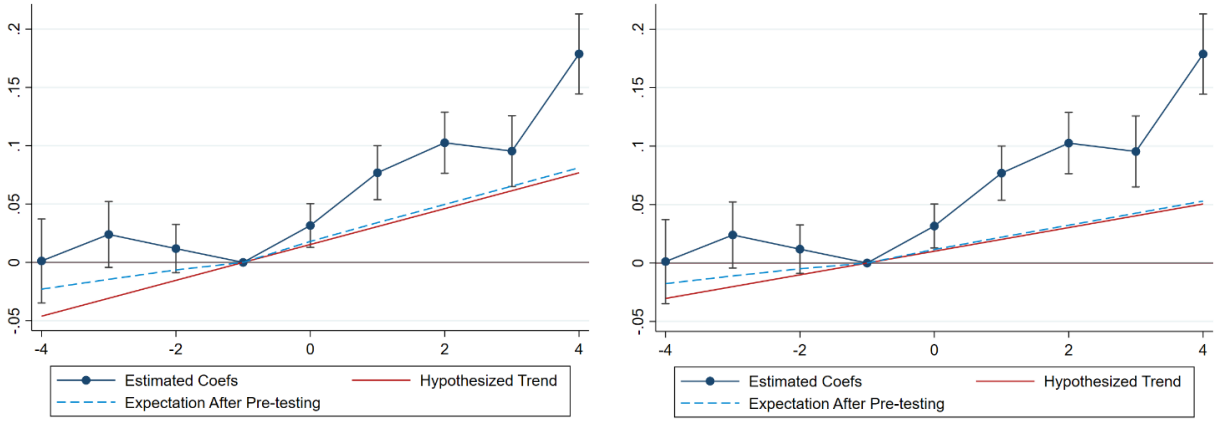
(b) Logarithm of stock holdings in different years

Figure 1: Effect of the 2017 Pension Reform on Stock Holdings

The figure provides the graphical illustration of $\{b_j\}_{j=-4}^{j=4}$ from Column (4) in Table 2 and Table 3, shown in Panel (a) and Panel (b), respectively. Panel (a) and Panel (b) depict the estimates of Equation (2) with the dependent variables *ln(Stock/Wealth)* and *ln(Stock Holdings)*, respectively. The dots represent the point estimates, and the bars denote the 95% confidence intervals. Relative Year 0 corresponds to 2017, when the reform legislation was passed, while Relative Year 1 corresponds to 2018, when the pension cuts for civil servants began.



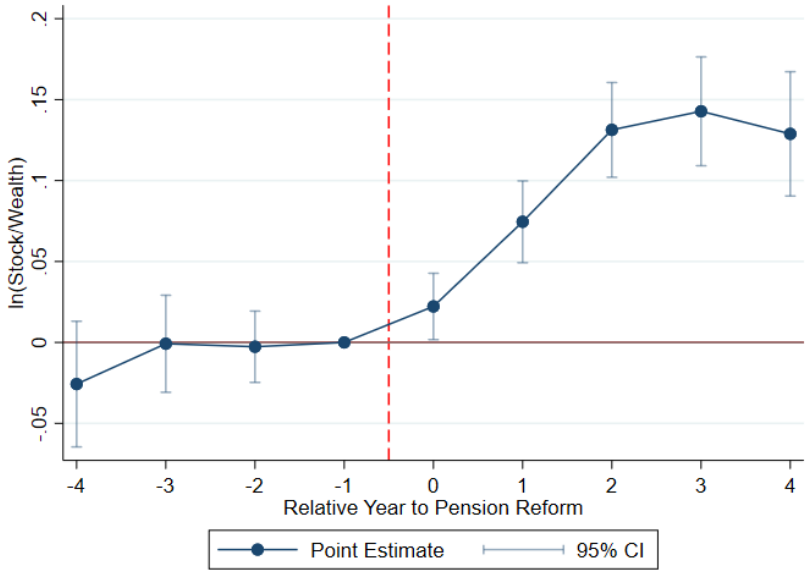
(a) Logarithm of stock-to-wealth ratio



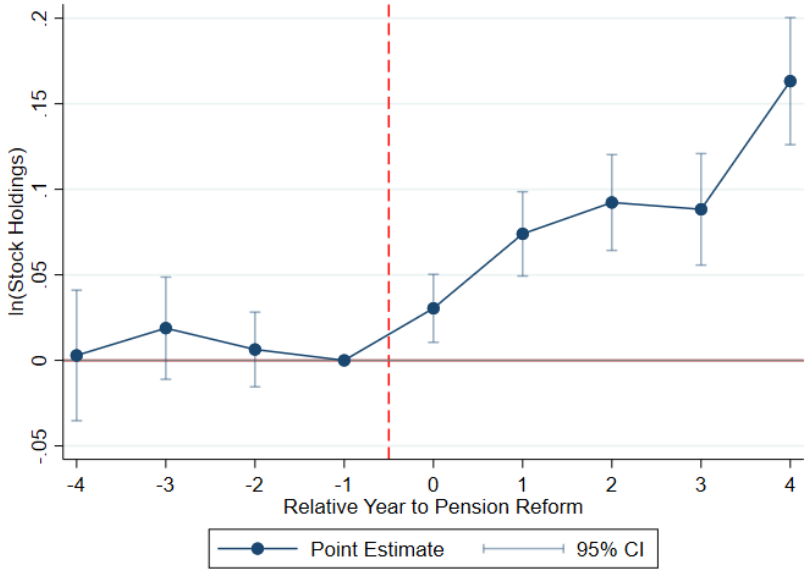
(b) Logarithm of stock holdings

Figure 2: Robustness Check for Pre-trend Testing

The figure presents the robustness test proposed by Roth (2022). We assume the existence of a linear trend and calculate the slope of the hypothesized trend based on 80% and 50% statistical power on the left and right plots, respectively. Panel (a) presents the results for *ln(Stock/Wealth)* and panel (b) presents the results for *ln(Stock Holdings)*. The horizontal axis denotes each year relative to 2017.



(a) Logarithm of stock-to-wealth ratio in different years



(b) Logarithm of stock holdings in different years

Figure 3: Robustness Check using Matched Sample

The figure provides the graphical illustration of $\{b_j\}_{j=-4}^{j=4}$ from Column (1) and Column (3) in Table 5, shown in Panel (a) and Panel (b), respectively. Panel (a) and Panel (b) depict the estimates of Equation (2) with the dependent variables *ln(Stock/Wealth)* and *ln(Stock Holdings)*, respectively, using the matched sample as a robustness check. The dots represent the point estimates, and the bars denote the 95% confidence intervals. Relative Year 0 corresponds to 2017, when the reform legislation was passed, while Relative Year 1 corresponds to 2018, when the pension cuts for civil servants began.

Table 1: Summary Statistics (2013-2016)

	N	mean	sd	p5	p25	p50	p75	p95
Panel A: Population								
Husband Age	459,822	61.11	4.232	55	57	61	64	68
Wife Age	459,822	57.65	5.324	50	54	58	61	66
Male Breadwinner	459,822	0.722	0.448	0	0	1	1	1
Unretire	459,822	0.277	0.447	0	0	1	1	1
Child Dependency	459,822	0.310	0.652	0	0	0	0	2
Deposits (thousands)	459,822	2,783	8988.4	0	0	177.8	2,236	14639
Bond (thousands)	459,822	2.515	244.4	0	0	0	0	0
Stock Holdings (thousands)	459,822	2,083	48135.3	0	0	50	864.7	6,825
Conditional Stock Holdings (thousands)	306,803	3,116	58904.5	1.476	46.31	404.8	1,779	9,639
I_stock	459,822	0.664	0.472	0	0	1	1	1
Present Value of Cars (thousands)	459,822	144.8	378.0	0	0	0	145.3	693
Assessed Value of Real Estate (thousands)	459,822	10,701	127392.6	0	1,537	4,367	10,287	34,646
Owning Real Estate	459,822	0.898	0.303	0	1	1	1	1
Mortgage (thousands)	459,822	293.1	2819.0	0	0	0	0	1,643
Total Wealth (thousands)	459,822	15,714	167613.0	2.380	2,449	6,814	16,204	50,039
Deposits/Wealth	441,719	0.168	0.855	0	0	0.00296	0.257	0.738
Stock/Wealth	441,719	0.116	3.162	0	0	0.0112	0.109	0.62
α_{CAPM}	306,803	-2.58	1.83	-5.57	-3.55	-2.68	-1.55	0.00
β_{CAPM}^{MKT}	306,803	0.02	0.03	0.00	0.00	0.01	0.03	0.08
$\sum\widehat{\epsilon^2}_{CAPM}$	306,803	7,106.63	16,955	0.00	282.46	2,296.30	8,164.95	28,593.09
α_{FF3}	306,803	-2.66	1.81	-5.48	-3.70	-2.84	-1.67	0.00
β_{FF3}^{MKT}	306,803	0.02	0.03	0.00	0.00	0.01	0.03	0.08
β_{FF3}^{SMB}	306,803	-0.01	0.04	-0.09	-0.03	0.00	0.00	0.03
β_{FF3}^{HML}	306,803	-0.04	0.24	-0.60	-0.00	0.00	0.03	0.14
$\sum\widehat{\epsilon^2}_{FF3}$	306,803	576.24	806.17	0.00	140.97	394.22	743.14	1,719.19
α_{FF5}	306,803	-2.41	1.78	-5.19	-3.44	-2.57	-1.15	0.00
β_{FF5}^{MKT}	306,803	0.02	0.03	0.00	0.00	0.01	0.03	0.08
β_{FF5}^{SMB}	306,803	-0.02	0.04	-0.10	-0.02	0.00	0.00	0.03
β_{FF5}^{HML}	306,803	-0.06	0.32	-0.68	-0.01	0.00	0.02	0.13
β_{FF5}^{RMW}	306,803	-0.02	0.04	-0.09	-0.04	-0.01	0.00	0.02
β_{FF5}^{CMA}	306,803	-1.45	0.70	-1.79	-1.79	-1.79	-1.79	0.00
$\sum\widehat{\epsilon^2}_{FF5}$	306,803	497.98	679.48	0.00	131.70	352.43	647.62	1,452.31
Realized Gains (thousands)	306,803	57.34	906.56	0.00	0.00	0.00	1.95	190.98
Realized Losses (thousands)	306,803	30.72	634.02	0.00	0.00	0.00	0.00	81.90
Paper Gains (thousands)	306,803	86.23	2972.95	0	0	0	10.12	197.37
Paper Losses (thousands)	306,803	59.57	3965.61	0	0	0	5.03	144.35

Proportion of Gains Realized	306,803	0.17	0.33	0.00	0.00	0.00	0.10	1.00
Proportion of Losses Realized	306,803	0.12	0.29	0.00	0.00	0.00	0.00	0.99
Panel B: Civil Servants								
Husband Age	52,839	61.96	4.356	55	58	62	66	69
Wife Age	52,839	58.72	5.285	50	55	59	63	67
Male Breadwinner	52,839	0.873	0.333	0	1	1	1	1
Unretire	52,839	0.139	0.346	0	0	0	0	1
Child Dependency	52,839	0.272	0.603	0	0	0	0	2
Deposits (thousands)	52,839	3,326	6819.0	0	0	790.1	3,197	16,299
Bond (thousands)	52,839	0.365	28.83	0	0	0	0	0
Stock Holdings (thousands)	52,839	1,148	5112.3	0	0	60.85	744.1	4,970
Conditional Stock Holdings (thousands)	36,652	1,643	6017.6	1.411	39.50	346.9	1,322	6,594
I_stock	52,839	0.692	0.462	0	0	1	1	1
Present Value of Cars (thousands)	52,839	145.8	316.7	0	0	0	190.8	658
Assessed Value of Real Estate (thousands)	52,839	10,354	25300.6	0	2,200	5,278	11,278	33,728
Owning Real Estate	52,839	0.942	0.233	0	1	1	1	1
Mortgage (thousands)	52,839	275.3	1461.1	0	0	0	0	1,777
Total Wealth (thousands)	52,839	14,975	28877.6	508.6	3,667	8,418	17,795	47,745
Deposits/Wealth	52,026	0.208	0.943	0	0	106	0.344	0.765
Stock/Wealth	52,026	0.0796	0.428	0	0	0.00826	0.0780	0.398
α_{CAPM}	36,652	-2.736	1.716	-5.534	-3.591	-2.773	-1.955	0
β_{CAPM}^{MKT}	36,652	0.0216	0.0323	0	0.00388	0.00805	0.0344	0.0782
$\sum\widehat{\epsilon^2}_{CAPM}$	36,652	8,022	18,069	0	564.7	2,990	9,236	31,165
α_{FF3}	36,652	-2.821	1.687	-5.450	-3.712	-2.922	-2.065	0
β_{FF3}^{MKT}	36,652	0.0248	0.0326	0	0.00521	0.0137	0.0369	0.0820
β_{FF3}^{SMB}	36,652	-0.0162	0.0396	-0.096	-0.0344	-0.0011	0.00449	0.0262
β_{FF3}^{HML}	36,652	-0.0467	0.249	-0.618	-0.0034	0.00677	0.0297	0.136
$\sum\widehat{\epsilon^2}_{FF3}$	36,652	607.6	804.9	0	213.2	428.9	763.2	1,727
α_{FF5}	36,652	-2.549	1.677	-5.151	-3.455	-2.658	-1.694	0
β_{FF5}^{MKT}	36,652	0.0244	0.0325	0	0.00485	0.0129	0.0362	0.0820
β_{FF5}^{SMB}	36,652	-0.0165	0.0432	-0.104	-0.0280	-0.0011	0.00415	0.0266
β_{FF5}^{HML}	36,652	-0.0639	0.318	-0.677	-0.0118	0.00310	0.0230	0.144
β_{FF5}^{RMW}	36,652	-0.0222	0.035	-0.087	-0.0377	-0.0131	0	0.0164
β_{FF5}^{CMA}	36,652	-1.548	0.607	-1.785	-1.785	-1.785	-1.785	0
$\sum\widehat{\epsilon^2}_{FF5}$	36,652	527.0	685.7	0	195.9	379.7	664.5	1,465
Realized Gains (thousands)	36,652	46.76	418.7	0	0	0	4.630	188.7
Realized Losses (thousands)	36,652	24.03	389.6	0	0	0	0	80.80
Paper Gains (thousands)	36,652	48.71	461.3	0	0	0	12.13	184.2
Paper Losses (thousands)	36,652	37.68	492.9	0	0	0	6.44	140.1

Proportion of Gains Realized	36,652	0.189	0.343	0	0	0	0.203	1.000
Proportion of Losses Realized	36,652	0.136	0.303	0	0	0	0	0.996
Panel C: Private Sector								
Husband Age	407,043	61	4.203	55	57	61	64	68
Wife Age	407,043	57.51	5.313	50	54	57	61	66
Male Breadwinner	407,043	0.703	0.457	0	0	1	1	1
Unretire	407,043	0.294	0.456	0	0	0	1	1
Child Dependency	407,043	0.315	0.658	0	0	0	0	2
Deposits (thousands)	407,043	2,712	9230.3	0	0	120.5	2,102	14,340
Bond (thousands)	407,043	2.794	259.5	0	0	0	0	0
Stock Holdings (thousands)	407,043	2,204	51129.9	0	0	49.22	885.6	7,093
Conditional Stock Holdings (thousands)	270,151	3,316	62731.5	1.485	47.58	414.7	1,859	10,058
I_stock	407,043	0.661	0.473	0	0	1	1	1
Present Value of Cars (thousands)	407,043	144.7	385.3	0	0	0	131.5	700.9
Assessed Value of Real Estate (thousands)	407,043	10,746	135101.7	0	1,453	4,245	10,139	34,758
Owning Real Estate	407,043	0.892	0.311	0	1	1	1	1
Mortgage (thousands)	407,043	295.5	2949.8	0	0	0	0	1,626
Total Wealth (thousands)	407,043	15,810	177856.0	0.310	2,307	6,596	15,984	50,406
Deposits/Wealth	389,693	0.163	0.842	0	0	0.0211	0.243	0.733
Stock/Wealth	389,693	0.121	3.363	0	0	0.0117	0.114	0.653
α_{CAPM}	270,151	-2.557	1.846	-5.571	-3.542	-2.666	-1.455	0
β_{CAPM}^{MKT}	270,151	0.0198	0.031	0	0.00258	0.00724	0.0256	0.0771
$\sum\widehat{\epsilon^2}_{CAPM}$	270,151	6,982	16,795	0	234.5	2,205	8,021	28,249
α_{FF3}	270,151	-2.643	1.827	-5.482	-3.695	-2.830	-1.588	0
β_{FF3}^{MKT}	270,151	0.0226	0.032	0	0.00321	0.0121	0.0297	0.0804
β_{FF3}^{SMB}	270,151	-0.0145	0.038	-0.094	-0.0238	0	0.00364	0.0261
β_{FF3}^{HML}	270,151	-0.0429	0.244	-0.596	-0.0018	0.00379	0.0281	0.135
$\sum\widehat{\epsilon^2}_{FF3}$	270,151	572.0	806.3	0	128.0	389.0	740.3	1,717
α_{FF5}	270,151	-2.392	1.796	-5.195	-3.442	-2.559	-1.011	0
β_{FF5}^{MKT}	270,151	0.0223	0.032	0	0.00282	0.0111	0.0304	0.0812
β_{FF5}^{SMB}	270,151	-0.0151	0.042	-0.104	-0.0197	0	0.00346	0.0264
β_{FF5}^{HML}	270,151	-0.0617	0.316	-0.677	-0.0077	0	0.0215	0.131
β_{FF5}^{RMW}	270,151	-0.0207	0.035	-0.086	-0.0357	-0.0107	0	0.0157
β_{FF5}^{CMA}	270,151	-1.433	0.711	-1.785	-1.785	-1.785	-1.785	0
$\sum\widehat{\epsilon^2}_{FF5}$	270,151	494.0	678.5	0	121.2	348.5	644.8	1,451
Realized Gains (thousands)	270,151	58.78	953.7	0	0	0	1.649	191.4
Realized Losses (thousands)	270,151	31.63	660.2	0	0	0	0	82.09
Paper Gains (thousands)	270,151	91.32	3,164	0	0	0	9.869	199.3
Paper Losses (thousands)	270,151	62.54	4,222	0	0	0	4.844	145.1

Proportion of Gains Realized	270,151	0.170	0.33	0	0	0	0.0900	0.999
Proportion of Losses Realized	270,151	0.122	0.291	0	0	0	0	0.990

This table presents the summary statistics for the entire sample before the pension reform, as well as for civil servants (the treated group) and their private sector counterparts (the control group). The numbers without parentheses are the mean coefficients and the numbers within parentheses are the standard deviations. *Husband Age* denotes the age of the husband in the household; *Wife Age* denotes the age of the wife in the household; *Male Breadwinner* denotes whether the primary breadwinner of the household was the husband; *Unretire* denotes whether the retired breadwinner receives annual labor income exceeding 100,000 NTD; *Child Dependency* denotes the number of children below 24 years old in the household; *Deposits* denotes the amount of household bank deposits; *Bond* denotes the amount of bond holdings of the household; *Stock Holdings* denotes the amount of stock holdings of the household; *Conditional Stock Holdings* reports the amount of stock holdings of the household that had held stock prior to the pension reform; *I_stock* denotes whether the household holds any stocks; *Present Value of Cars* denotes the present value of cars of the household; *Assessed Value of Real Estate* denotes the assessed value of houses and land minus the outstanding mortgages of the household; *Owning Real Estate* denotes whether the household holds any real estate; *Mortgage* denotes the outstanding mortgages of the household; *Total Wealth* denotes the total wealth of the household; *Deposits/Wealth* denotes the deposits-to-wealth ratio; *Stock/Wealth* denotes the stock-to-wealth ratio; α_m denotes the weighted average of the household stock portfolio's α under asset pricing model m; β_m^k denotes the weighted average of the household stock portfolio's β of factor *k* under asset pricing model m; and $\sum \widehat{\epsilon^2}_m$ denotes the weighted average of the household stock portfolio's idiosyncratic risk under asset pricing model *m*. All variables are defined in Table A2 in Appendix.

Table 2: Effect of the 2017 Pension Reform on the Stock-to-Wealth Ratio

	(1) ln(Stock/ Wealth)	(2) ln(Stock/ Wealth)	(3) ln(Stock/ Wealth)	(4) ln(Stock/ Wealth)	(5) ln(Stock/ Wealth)
Civil Servant × Post	0.1058***	0.1035***	0.1014***		
	(0.0114)	(0.0114)	(0.0114)		
Child Dependency		-0.0005	-0.0024	-0.0005	-0.0024
		(0.0059)	(0.0059)	(0.0059)	(0.0059)
ln(1+mortgage)		0.0220***	0.0219***	0.0219***	0.0219***
		(0.0005)	(0.0005)	(0.0005)	(0.0005)
Civil Servant × $I[t-2017=-4]$				-0.0025	0.0027
				(0.0187)	(0.0188)
Civil Servant × $I[t-2017=-3]$				0.0164	0.0204
				(0.0145)	(0.0145)
Civil Servant × $I[t-2017=-2]$				0.0060	0.0064
				(0.0107)	(0.0107)
Civil Servant × $I[t-2017=0]$				0.0296***	0.0293***
				(0.0099)	(0.0100)
Civil Servant × $I[t-2017=1]$				0.0868***	0.0860***
				(0.0122)	(0.0122)
Civil Servant × $I[t-2017=2]$				0.1487***	0.1496***
				(0.0140)	(0.0141)
Civil Servant × $I[t-2017=3]$				0.1627***	0.1616***
				(0.0160)	(0.0161)
Civil Servant × $I[t-2017=4]$				0.1633***	0.1623***
				(0.0182)	(0.0183)
Husband Age FE	-	Y	Y	Y	Y
Household FE	Y	Y	Y	Y	Y
Year FE	Y	Y	-	Y	-
City-Year FE	-	-	Y	-	Y
Observations	799906	799906	799906	799906	799906

This table examines the impact of the 2017 pension reform on the stock-to-wealth ratio of the civil servant families. The sample period is from 2013 to 2021, and we focus on a sample of households that had held stocks prior to the pension reform so as to leave out the effect of the pension reform on the retirees' participation in stock markets here. The dependent variable is the natural logarithm of *Stock/Wealth*, which reflects the intensity of financial market participation. Column (1) to Column (3) report the estimates of Equation (1), while Column (4) and Column (5) report the estimates of Equation (2). Standard errors are clustered at the household level and are shown in the parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 3: Effect of the 2017 Pension Reform on Stock Holdings

	(1) ln(Stock Holdings)	(2) ln(Stock Holdings)	(3) ln(Stock Holdings)	(4) ln(Stock Holdings)	(5) ln(Stock Holdings)
Civil Servant × Post	0.0760***	0.0803***	0.0762***		
	(0.0110)	(0.0110)	(0.0111)		
Child Dependency		-0.0064	-0.0086	-0.0065	-0.0086
		(0.0058)	(0.0058)	(0.0058)	(0.0058)
ln(1+mortgage)		-0.0004	-0.0005	-0.0004	-0.0005
		(0.0004)	(0.0004)	(0.0004)	(0.0004)
Civil Servant × $I[t-2017=-4]$				0.0013	0.0038
				(0.0183)	(0.0184)
Civil Servant × $I[t-2017=-3]$				0.0240*	0.0264*
				(0.0144)	(0.0144)
Civil Servant × $I[t-2017=-2]$				0.0118	0.0121
				(0.0106)	(0.0106)
Civil Servant × $I[t-2017=0]$				0.0316***	0.0299***
				(0.0096)	(0.0096)
Civil Servant × $I[t-2017=1]$				0.0769***	0.0740***
				(0.0118)	(0.0119)
Civil Servant × $I[t-2017=2]$				0.1026***	0.1005***
				(0.0134)	(0.0134)
Civil Servant × $I[t-2017=3]$				0.0954***	0.0908***
				(0.0155)	(0.0155)
Civil Servant × $I[t-2017=4]$				0.1787***	0.1731***
				(0.0175)	(0.0176)
Husband Age FE	-	Y	Y	Y	Y
Household FE	Y	Y	Y	Y	Y
Year FE	Y	Y	-	Y	-
City-Year FE	-	-	Y	-	Y
Observations	803558	803558	803558	803558	803558

This table examines the impact of the 2017 pension reform on the stock holdings of the civil servant families. The sample period is from 2013 to 2021, and we focus on a sample of households that had held stocks prior to the pension reform so as to leave out the effect of the pension reform on the retirees' participation in stock markets here. The dependent variable is the natural logarithm of *Stock Holdings*, which reflects the intensity of financial market participation. Column (1) to Column (3) report the estimates of Equation (1); Column (4) and Column (5) report the estimates of Equation (2). Standard errors are clustered at the household level and are shown in the parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 4: Summary Statistics of Matched Sample

	(1) Civil Servants	(2) Private Sector	(3) Difference
Total Wealth (thousands)	15142.92	15476.29	333.36
I_stock	0.68	0.69	0.01*
Stock/Wealth	0.08	0.08	0.01*
Deposits/Wealth	0.20	0.20	0.01
α_{CAPM}	-2.25	-2.26	-0.00
β_{CAPM}^{MKT}	0.05	0.05	-0.00
$\sum\widehat{\epsilon^2}_{CAPM}$	8317.93	7680.65	-637.28**
α_{FF3}	-2.63	-2.62	0.01
β_{FF3}^{MKT}	0.05	0.05	-0.00
β_{FF3}^{SMB}	0.01	0.01	-0.00**
β_{FF3}^{HML}	0.02	0.02	-0.00
$\sum\widehat{\epsilon^2}_{FF3}$	632.36	589.31	-43.05***
α_{FF5}	-2.64	-2.63	0.01
β_{FF5}^{MKT}	0.05	0.05	-0.00
β_{FF5}^{SMB}	0.01	0.01	-0.00*
β_{FF5}^{HML}	0.01	0.01	-0.00
β_{FF5}^{RMW}	-0.01	-0.01	0.00*
β_{FF5}^{CMA}	-1.56	-1.54	0.02**
$\sum\widehat{\epsilon^2}_{FF5}$	550.18	511.45	-38.73***
Realized Gains (thousands)	42.28	44.54	2.26
Realized Losses (thousands)	16.97	13.48	-3.49
Paper Gains (thousands)	48.24	58.60	10.36**
Paper Losses (thousands)	19.78	25.68	5.90
Proportion of Gains Realized	0.17	0.17	0.00
Proportion of Losses Realized	0.10	0.10	-0.00
Deposits (thousands)	3060.65	3544.71	484.06***
Bond (thousands)	0.06	0.88	0.82**
Stock Holdings (thousands)	1099.90	1346.83	246.93***
Conditional Stock Holdings (thousands)	1612.97	1949.24	336.27***
Present Value of Cars (thousands)	146.63	149.12	2.49
Assessed Value of Real Estates (thousands)	10835.68	10434.75	-400.93
Owning Real Estates	0.94	0.96	0.02***
Mortgage (thousands)	289.46	273.44	-16.03
Husband Age	62.27	62.10	-0.17***
Wife Age	59.09	58.93	-0.15***
Male Breadwinner	0.88	0.87	-0.01***
Unretire	0.12	0.42	0.03***
Child Dependency	0.26	0.25	-0.01*
Observations	18429	54108	72537

This table presents the summary statistics for the matched sample before the pension reform. The matched sample is constructed by matching each retired civil servant family with their three nearest private sector counterparts using the Mahalanobis distance. This matching is based on the following observable characteristics in 2016, the year right before the pension reform: *Husband Age, Wife Age, Male Breadwinner, Unretire, Child Dependency, ln(1+Deposits), ln(1+Stock Holdings), ln(1+Total Wealth), Deposits/Wealth, Stock/Wealth,* α_{CAPM}, β_{CAPM}^{MKT}, and $\sum\widehat{\epsilon^2}_{CAPM}$. The three

matched nearest neighbors of each retired civil servant family are then included as the matched control group in the matched sample. Column (1) shows the mean of the treated group, Column (2) shows the mean of the matched control group, and Column (3) presents the results of a two-sample t-test of the null hypothesis that the two groups are the same. The estimated coefficient p-values are indicated using the following notation: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. All variables are defined in Table A2 in Appendix.

Table 5: Robustness Check based on A Matched Sample

	(1) ln(Stock/ Wealth)	(2) ln(Stock/ Wealth)	(3) ln(Stock Holdings)	(4) ln(Stock Holdings)
Child Dependency	0.0036	0.0007	0.0021	-0.0007
	(0.0099)	(0.0099)	(0.0099)	(0.0099)
ln(1+mortgage)	0.0208***	0.0207***	0.00006	0.000008
	(0.0006)	(0.0006)	(0.0006)	(0.0006)
Civil Servant × $I[t-2017=-4]$	-0.0257	-0.0246	0.0029	0.0049
	(0.0198)	(0.0198)	(0.0195)	(0.0194)
Civil Servant × $I[t-2017=-3]$	-0.0008	-0.0006	0.0188	0.0198
	(0.0153)	(0.0153)	(0.0152)	(0.0152)
Civil Servant × $I[t-2017=-2]$	-0.0027	-0.0027	0.0064	0.0066
	(0.0113)	(0.0113)	(0.0111)	(0.0111)
Civil Servant × $I[t-2017=0]$	0.0223**	0.0222***	0.0304***	0.0304***
	(0.0105)	(0.0104)	(0.0101)	(0.0101)
Civil Servant × $I[t-2017=1]$	0.0745***	0.0746***	0.0740***	0.0740***
	(0.0129)	(0.0129)	(0.0126)	(0.0126)
Civil Servant × $I[t-2017=2]$	0.1313***	0.1319***	0.0923***	0.0928***
	(0.0149)	(0.0149)	(0.0143)	(0.0143)
Civil Servant × $I[t-2017=3]$	0.1428***	0.1428***	0.0883***	0.0884***
	(0.0172)	(0.0171)	(0.0166)	(0.0166)
Civil Servant × $I[t-2017=4]$	0.1288***	0.1285***	0.1632***	0.1627***
	(0.0196)	(0.0196)	(0.0189)	(0.0189)
Husband Age FE	Y	Y	Y	Y
Household FE	Y	Y	Y	Y
Year FE	Y	-	Y	-
City-Year FE	-	Y	-	Y
Observations	349509	349509	350402	350402

This table examines the impact of the 2017 pension reform on the stock holdings of the civil servant families, using the matched sample as a robustness check. The sample period is from 2013 to 2021, and we focus on a sample of households that had held stocks prior to the pension reform so as to leave out the effect of the pension reform on the retirees' participation in stock markets here. The table report the estimates of Equation (2), with the dependent variable being the natural logarithm of *Stock/Wealth* in Column (1) and Column (2) and the dependent variable being the natural logarithm of *Stock Holdings* in Column (3) and Column (4). Standard errors are clustered at the household level and are shown in the parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 6: Effect of the 2017 Pension Reform on Risk Exposure (CAPM)

	(1)	(2)	(3)	(4)	(5)	(6)
	α_{CAPM}	β_{CAPM}^{MKT}	$\sum\widehat{\epsilon^2}_{CAPM}$	α_{CAPM}	β_{CAPM}^{MKT}	$\sum\widehat{\epsilon^2}_{CAPM}$
Civil Servant × Post	0.0405***	0.0032***	269.59*	0.0379***	0.0034***	288.04*
	(0.0115)	(0.0003)	(148.63)	(0.01152)	(0.0003)	(148.6)
Child Dependency	-0.021***	-0.0005***	-240.52***	-0.0199***	-0.0005***	-240.80***
	(0.0063)	(0.0002)	(75.83)	(0.0063)	(0.0003)	(76.218)
ln(1+mortgage)	0.0002	-0.00001	-0.9292	0.0002	-0.00001	-0.9373
	(0.0005)	(0.00001)	(6.1418)	(0.0005)	(0.00001)	(6.1461)
Husband Age FE	Y	Y	Y	Y	Y	Y
Household FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	-	-	-
City-Year FE	-	-	-	Y	Y	Y
Observations	803558	803558	803558	803558	803558	803558

This table examines the impact of the 2017 pension reform on the stock portfolios of the civil servant families. The sample period is from 2013 to 2021, and we focus on a sample of households that had held stocks prior to the pension reform so as to leave out the effect of the pension reform on the retirees' participation in stock markets here. The dependent variables are portfolio alpha α_{CAPM}, market beta β_{CAPM}^{MKT}, *and* idiosyncratic risk $\sum\widehat{\epsilon^2}_{FF3}$, all derived from the Capital Asset Pricing Model. Column (1) to Column (3) report the estimates of Equation (1). Standard errors are clustered at the household level and are shown in the parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 7: Effect of the 2017 Pension Reform on Risk Exposure (FF3)

	(1)	(2)	(3)	(4)	(5)
	α_{FF3}	β_{FF3}^{MKT}	β_{FF3}^{SMB}	β_{FF3}^{HML}	$\sum\widehat{\epsilon^2}_{FF3}$
Panel A: Controlling for Household FE and Year FE					
Civil Servant	0.0156	0.0031***	0.0022***	0.0064***	14.870*
× Post	(0.0118)	(0.0003)	(0.0003)	(0.0013)	(8.3468)
Child	-0.01489**	-0.0005***	-0.0005***	-0.002***	-4.2879
Dependency	(0.006225)	(0.0002)	(0.0002)	(0.0007782)	(4.6994)
ln(1+mortgage)	0.0001344	-0.00001	0.00003**	-0.00006	0.5147
	(0.0004663)	(0.00001)	(0.00001)	(0.00005864)	(0.4004)
Panel B: Controlling for Household FE and City-Year FE					
Civil Servant	0.0135	0.0033***	0.0023***	0.0065***	14.928*
× Post	(0.01185)	(0.0003)	(0.0003)	(0.0013)	(8.3692)
Child	-0.014**	-0.0004***	-0.0004***	-0.0019**	-4.0304
Dependency	(0.0062)	(0.0002)	(0.0002)	(0.0008)	(4.7013)
ln(1+mortgage)	0.0002	-0.00001	0.00003**	-0.00006	0.5240
	(0.0005)	(0.00001)	(0.00001)	(0.00006)	(0.4007)
Husband Age FE	Y	Y	Y	Y	Y
Household FE	Y	Y	Y	Y	Y
Observations	803558	803558	803558	803558	803558

This table examines the impact of the 2017 pension reform on the stock portfolios of the civil servant families. The sample period is from 2013 to 2021, and we focus on a sample of households that had held stocks prior to the pension reform so as to leave out the effect of the pension reform on the retirees' participation in stock markets here. The dependent variables are portfolio alpha α_{FF3}, market beta β_{FF3}^{MKT}, size beta β_{FF3}^{SMB}, value beta β_{FF3}^{SMB}, *and* idiosyncratic risk $\sum\widehat{\epsilon^2}_{FF3}$, all derived from the Fama-French three-factor model. Panel A reports the conventional two-way fixed effects estimates of Equation (1), while Panel B replaces the year fixed effect with city-year fixed effect to account for time-varying local factors. Standard errors are clustered at the household level and are shown in the parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 8: Effect of the 2017 Pension Reform on Risk Exposure (FF5)

	(1)	(2)	(3)	(4)	(6)	(7)	(8)
	α_{FF5}	β_{FF5}^{MKT}	β_{FF5}^{SMB}	β_{FF5}^{HML}	β_{FF5}^{RMW}	β_{FF5}^{CMA}	$\sum\widehat{\epsilon^2}_{FF5}$
Panel A: Controlling for Household FE and Year FE							
Civil Servant × Post	0.0091	0.0031***	0.0020***	0.0055***	0.0008**	0.0027	11.770
	(0.0132)	(0.0003)	(0.0003)	(0.0018)	(0.0003)	(0.0025)	(7.5545)
Child Dependency	-0.016**	-0.0004***	-0.0004**	-0.0015	-0.0002	0.0011	-2.235
	(0.0069)	(0.0002)	(0.0002)	(0.0011)	(0.0002)	(0.0014)	(4.22)
ln(1+mortgage)	0.0002	-0.00001	0.00003*	-0.00009	0.000007	0.00007	0.3714
	(0.0005)	(0.00001)	(0.00001)	(0.00008)	(0.00002)	(0.0001)	(0.3623)
Panel B: Controlling for Household FE and City-Year FE							
Civil Servant × Post	0.0078	0.0032***	0.0020***	0.0055***	0.0008**	0.0032	11.597
	(0.0132)	(0.0003)	(0.0003)	(0.0018)	(0.0003)	(0.0025)	(7.58)
Child Dependency	-0.0153**	-0.0004**	-0.0004**	-0.0013	-0.0002	0.0014	-2.092
	(0.0069)	(0.0002)	(0.0002)	(0.0011)	(0.0002)	(0.0014)	(4.221)
ln(1+mortgage)	0.0003	-0.00001	0.00003*	-0.00009	0.000007	0.00008	0.3777
	(0.0005)	(0.00001)	(0.00001)	(0.00008)	(0.00002)	(0.0001)	(0.3625)
Husband Age FE	Y	Y	Y	Y	Y	Y	Y
Household FE	Y	Y	Y	Y	Y	Y	Y
Observations	803558	803558	803558	803558	803558	803558	803558

This table examines the impact of the 2017 pension reform on the stock portfolios of the civil servant families. The sample period is from 2013 to 2021, and we focus on a sample of households that had held stocks prior to the pension reform so as to leave out the effect of the pension reform on the retirees' participation in stock markets here. The dependent variables are portfolio alpha α_{FF5}, market beta β_{FF5}^{MKT}, size beta β_{FF5}^{SMB}, value β_{FF5}^{HML}, profitability beta β_{FF5}^{RMW}, investment beta β_{FF5}^{CMA}, and idiosyncratic risk $\sum\widehat{\epsilon^2}_{FF5}$, all derived from Fama-French five-factor model. Panel A reports the conventional two-way fixed effects estimates of Equation (1), while Panel B replaces the year fixed effect with city-year fixed effect to account for time-varying local factors. Standard errors are clustered at the household level and are shown in the parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 9: Effect of the 2017 Pension Reform on Realized Gains and Losses

	(1)	(2)	(3)
Panel A		ln(1+Realize Gains)	
Civil Servant × Post	0.2455***	0.2750***	0.2782***
	(0.03564)	(0.03528)	(0.03542)
Child Dependency		-0.1047***	-0.1079***
		(0.01847)	(0.01848)
ln(1+mortgage)		0.001999	0.001884
		(0.001549)	(0.001549)
	(1)	(2)	(3)
Panel B		ln(1+Realize Losses)	
Civil Servant × Post	0.1139***	0.1351***	0.1342***
	(0.03026)	(0.03002)	(0.03016)
Child Dependency		-0.03883**	-0.04184***
		(0.01526)	(0.01527)
ln(1+mortgage)		-0.001658	-0.001683
		(0.001364)	(0.001364)
Husband Age FE	-	Y	Y
Household FE	Y	Y	Y
Year FE	Y	Y	-
City-Year FE	-	-	Y
Observations	803558	803558	803558

This table examines the impact of the 2017 pension reform on the realized gains and losses among retired civil servant households. The sample period is from 2013 to 2021, and we focus on a sample of households that had held stocks prior to the pension reform so as to leave out the effect of the pension reform on the retirees' participation in stock markets here. The dependent variables are *ln(1+Realized Gains)* in Panel A and *ln(1+Realized Losses)* in Panel B, which capture patterns of stock-selling behavior. Column (1) to Column (3) report the estimates of Equation (1). Standard errors are clustered at the household level and are shown in the parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 10: Effect of the 2017 Pension Reform on the Disposition Effect

	(1)	(2)	(3)
Panel A	Proportion of Gains Realized		
Civil Servant × Post	0.0108***	0.0129***	0.0129***
	(0.0026)	(0.003)	(0.0026)
Child Dependency		-0.0046***	-0.0048***
		(0.0013)	(0.0013)
ln(1+mortgage)		0.0002	0.0002
		(0.0001)	(0.0001)
	(1)	(2)	(3)
Panel B	Proportion of Losses Realized		
Civil Servant × Post	0.0045**	0.006***	0.0059**
	(0.0023)	(0.0023)	(0.0023)
Child Dependency		-0.0018	-0.002
		(0.0012)	(0.0012)
ln(1+mortgage)		-0.00004	-0.00004
		(0.0001)	(0.0001)
Husband Age FE	-	Y	Y
Household FE	Y	Y	Y
Year FE	Y	Y	-
City-Year FE	-	-	Y
Observations	803558	803558	803558

This table examines the impact of the 2017 pension reform on the disposition effect among retired civil servant households. The sample period is from 2013 to 2021, and we focus on a sample of households that had held stocks prior to the pension reform so as to leave out the effect of the pension reform on the retirees' participation in stock markets here. The dependent variables are *Proportion of Gains Realized* (PGR) in Panel A and *Proportion of Losses Realized* (PLR) in Panel B, which capture patterns of stock-selling behavior. Column (1) to Column (3) report the estimates of Equation (1). Standard errors are clustered at the household level and are shown in the parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 11: Effect of the 2017 Pension Reform on Intensity of Stock Holdings – Subgroup Analysis

# Children	0	1	≥2	0	1	≥2
	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Stock/Wealth)	ln(Stock/Wealth)	ln(Stock/Wealth)	ln(Stock Holdings)	ln(Stock Holdings)	ln(Stock Holdings)
Civil Servant × Post	0.0900***	0.1467***	0.1844***	0.0760***	0.1256***	0.1260**
	(0.0126)	(0.0361)	(0.0657)	(0.0121)	(0.0351)	(0.0621)
Child Dependency			0.0079			-0.0043
			(0.0214)			(0.0203)
ln(1+mortgage)	0.0216***	0.0240***	0.0225***	-0.0005	0.0003	-0.0006
	(0.0005)	(0.0014)	(0.0019)	(0.0005)	(0.0013)	(0.0017)
Husband Age FE	Y	Y	Y	Y	Y	Y
Household FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Observations	636962	110062	52882	639881	110561	53116

This table examines the impact of the 2017 pension reform on the stock-to-wealth ratio and the stock holdings of the civil servant families by dividing the sample into subgroups. The sample period is from 2013 to 2021, and we focus on a sample of households that had held stocks prior to the pension reform so as to leave out the effect of the pension reform on the retirees' participation in stock markets here. The dependent variable is the natural logarithm of *Stock/Wealth*, or else the natural logarithm of *Stock Holdings*, which reflects the intensity of financial market participation. The table reports the estimates of Equation (1). Column (1) and Column (4) focus on the sample of households without children of dependency age, Column (2) and Column (5) focus on the sample of households with one child of dependency age, and Column (3) and Column (6) focus on the sample of households with two or more children of dependency age. Standard errors are clustered at the household level and are shown in the parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 12: Effect of the 2017 Pension Reform on Stock Market Participation

	(1)	(2)	(3)
	I_stock	I_stock	I_stock
Civil Servant × Post	0.0052***	0.0057***	0.0054***
	(0.0014)	(0.0014)	(0.0014)
Child Dependency		-0.0006	-0.0006
		(0.0007)	(0.0007)
ln(1+mortgage)		-0.000004	-0.000001
		(0.000054)	(0.000053)
Husband Age FE	-	Y	Y
Household FE	Y	Y	Y
Year FE	Y	Y	-
City-Year FE	-	-	Y
Observations	1256864	1256864	1256864

This table examines the impact of the 2017 pension reform on the financial market participation of the civil servant families. The sample period is from 2013 to 2021. The dependent variable is *I_stock*, which reflects the extensive margin of financial market participation. Column (1) to Column (3) report the estimates of Equation (1). Standard errors are clustered at the household level and are shown in the parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 13: Effect of the Pension Reform on the Deposits-to-Wealth Ratio

	(1)	(2)	(3)
	ln(Deposits/Wealth)	ln(Deposits/Wealth)	ln(Deposits/Wealth)
Civil Servant × Post	-0.2232***	-0.2266***	-0.2231***
	(0.0082)	(0.0082)	(0.0082)
Child Dependency		0.0029	0.0037
		(0.0053)	(0.0053)
ln(1+mortgage)		0.0147***	0.0148***
		(0.0004)	(0.0004)
Husband Age FE	-	Y	Y
Household FE	Y	Y	Y
Year FE	Y	Y	-
City-Year FE	-	-	Y
Observations	636514	636514	636514

This table examines the impact of the 2017 pension reform on the deposits-to-wealth of the civil servant families. The sample period is from 2013 to 2021. The dependent variable is the natural logarithm of *Deposits/Wealth*, which reflects the precautionary savings relative to the total wealth of the household. Column (1) to Column (3) report the estimates of Equation (1). Standard errors are clustered at the household level and are shown in the parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 14: Effect of the Pension Reform on Total Wealth

	(1) ln(1+ Total Wealth)	(2) ln(1+ Total Wealth)	(3) ln(1+ Total Wealth)
Civil Servant × Post	-0.0411***	-0.0330***	-0.0367***
	(0.00925)	(0.00923)	(0.00935)
Child Dependency		-0.0196***	-0.0197***
		(0.00650)	(0.00651)
ln(1+mortgage)		-0.0213***	-0.0213***
		(0.000333)	(0.000333)
Husband Age FE	-	Y	Y
Household FE	Y	Y	Y
Year FE	Y	Y	-
City-Year FE	-	-	Y
Observations	1249869	1249869	1249869

This table examines the impact of the 2017 pension reform on the amount of total wealth of the civil servant families. The sample period is from 2013 to 2021. The dependent variable is the natural logarithm of one plus *Total Wealth*. Column (1) to Column (3) report the estimates of Equation (1). Standard errors are clustered at the household level and are shown in parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.

Table 15: Effect of the 2017 Pension Reform on Post-retirement Jobs

	(1) Unretire	(2) Unretire	(3) Unretire
Civil Servant × Post	0.0459***	0.0465***	0.0474***
	(0.00207)	(0.00207)	(0.00209)
Child Dependency		0.00669***	0.00633***
		(0.00132)	(0.00133)
ln(1+mortgage)		0.0000326	0.0000230
		(0.000110)	(0.000110)
Husband Age FE	-	Y	Y
Household FE	Y	Y	Y
Year FE	Y	Y	-
City-Year FE	-	-	Y
Observations	1256864	1256864	1256864

This table examines the impact of the 2017 pension reform on post-retirement jobs of the civil servant families. The sample period is from 2013 to 2021. The dependent variable is *Unretire*, which reflects the labor supply on the extensive margin of the retired breadwinner. Column (1) to Column (3) report the estimates of Equation (1). Standard errors are clustered at the household level and are shown in parentheses. The estimated coefficient p-values are indicated using the following notation: * p<0.10, ** p<0.05, *** p<0.01. All variables are defined in Table A2 in Appendix.