THREE ESSAYS ON HOUSEHOLD PORTFOLIO CHOICE: THE ROLE OF MEDICAL EXPENDITURE RISK, SUBJECTIVE LIFESPAN, AND COGNITIVE ABILITIES.

by

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(Under the direction of Patryk Babiarz)

ABSTRACT

This dissertation considers household portfolio choice at the end of life-cycle. Three essays examine the importance of uncertainty about medical expenditure risk, cognitive aging, and subjective life horizon, and their role in explaining late-life savings decisions and portfolio allocation.

Chapter 2 of the dissertation, entitled "Medical expenditure risk and precautionary saving: Evidence from Medicare Part D", tests the presence of precautionary saving motive to cope with medical expenditure risk. By examining Medicare Part D and it's association with household saving, I demonstrate that social insurance programs discourage private saving by reducing health-related uncertainty. Chapter 3 of the dissertation, entitled "Econometric analysis of cognitive abilities and portfolio choice", explores the role of cognitive aging in explaining a portfolio rebalancing towards safer assets at the end of life-cycle. In this essay, I argue that a gradual decrease in risky asset ownership at the end of life-cycle is in part driven by losing cognitive capabilities. I pay particular attention to testing whether such association is observed only on the extensive margin - that is, changes in ownership, or both risky asset ownership and reallocation across the intensive margin are affected. Causality is tested by exploiting exogenous variation in cognitive health, created by the introduction of

Medicare Part D in 2006. Chapter 4 of the dissertation, entitled "Subjective life expectancy and portfolio choice: A household bargaining approach", examines collective decision-making when spouses have an incentive to bargain over portfolio allocation. This article starts with two well-known facts: (a) difference in life expectancy between husband and wife; and (b) age disparity in marriage. These two facts imply that females, on average, face 5 or 6 years longer retirement period to finance, and thus have more incentive to hold risky assets to achieve higher expected capital gains in the long-term. A difference in life expectancy then creates an incentive to bargain over how to allocate savings to risky and non-risky assets. The estimation results indeed show that more financial wealth is allocated to risky assets when a spouse with longer life expectancy has the "final say".

Index words: Portfolio choice, Risky investment, Precautionary saving, Cognitive aging, Subjective life expectancy, Bargaining power

Three essays on household portfolio choice: The role of medical expenditure risk, subjective lifespan, and cognitive abilities.

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Chapter 1

Introduction

This dissertation consists of three essays covering savings and portfolio choice issues at the end of life-cycle, with a particular focus on the determinants of risky asset ownership.

The first essay, entitled "Medical expenditure risk and precautionary saving: Evidence from Medicare Part D", revisits the issue of precautionary saving motive among the elderly using novel empirical strategy. Building on the clinical evidence, I argue that greater access to prescription drugs after the implementation of Medicare Part D significantly lowered the uncertainty about medical expenditure risk. Medicare Part D, taking all the provisions together, represents the largest expansion of an entitlement program since the program's inception in 1965. The timing of policy implementation, in conjunction with the longitudinal nature of data, allows me to implement a quasi-experimental study that isolates the treatment effect of additional prescription drug coverage. To test the hypothesis, I analyze data from the Health and Retirement Study which provides the rich information on the elderly who about to retire or within a few years of retirement. This sample selection has a particular importance because at this time of life-cycle individuals have the most savings and they are less likely to set aside emergency funds. Overall, the findings are in line with the literature delved into the precautionary motive to save.

The second essay, entitled "Econometric analysis of cognitive abilities and portfolio choice", examines the extent to which cognitive aging affects the riskiness of household portfolio. While a body of literature pointed out cognitive aging as one of the reasons old investors leave the equity market, the mechanism through which cognitive impairment crowds out risky investments is not well understood. More importantly, the question of whether declining cognitive ability is causally related to a less risky portfolio has not been answered convincingly. This aspect adds additional complexity to an understanding of mechanism because a lower stock ownership among the cognitively impaired could be due to cognitive aging *per se* or its impact on other preference features that move along the aging curve. To begin with, I first review and identify two conflicting arguments that explain the mechanism - that is, preference-based and non-preference based. The empirical analysis deals with three issues: (a) whether the causality runs from declining cognitive skills to a less risky portfolio; (b) whether such association is due to extensive changes in risky asset ownership or a rebalancing between existing financial assets with different risk contents; and (c) which mechanism explains such causal link. My findings are informative and generally in support of the literature. First, I find that the effect of cognitive aging is significant only on risky asset ownership, not on the proportion of risky assets. This result remains robust irrespective of modeling assumptions and definitions of cognitive capabilities. Second, the impact of cognitive aging on risky asset ownership is likely to be causal among less educated individuals. Third, declining cognitive ability does not work through its effect upon preferences.

The third essay, entitled "Subjective life expectancy and portfolio choice: A household bargaining approach", explores the association between husband's and wife's life expectancy and the riskiness of family portfolio. This essay is motivated by two well-known facts: women live longer than men, and most wives are younger than husbands. In theory, wives who expect a longer lifespan ought to be better off with risky portfolio because stocks are less risky over longer investment horizons and almost always more profitable than riskless assets. Faced with a relatively short lifespan, husbands may prefer to purchase goods and services that enhance utility immediately or invest in health in order to prolong their lifespan, even though a marginal increase in longevity is trivial. In either case, husbands with a shorter horizon have an incentive to liquidate resources held in illiquid financial assets or other forms of fixed assets to meet their present consumption needs. Assuming collective bargaining framework, I test whether the riskiness of portfolio is more responsive to the changes in the subjective horizon of a decision-making spouse. To capture individuals' subjective horizon, I utilize the subjective survival probability questions in the HRS, which measures the perceived likelihood of survival to a certain age. Across the models, I find that the share of financial wealth held in risky assets increases with the subjective survival probability of decision-making spouse.

Chapter 2

Essay I: Medical expenditure risk and precautionary saving: Evidence from Medicare Part D

2.1 Introduction

The theory of precautionary demand for savings predicts that individuals save not only to smooth consumption but also to cope with uncertainty regarding future income (Leland, 1968; Sandmo, 1970). In the precautionary savings model, people face the risk of adverse events happening in the future such as losing a job, becoming divorced/widowed, retiring earlier than expected, or even facing poor macroeconomic conditions. With the presence of consumption-smoothing motive, a rational choice of forward-looking individuals is to delay consumption and save in the current period to maintain some level of utility in the future (Hubbard, Skinner, & Zeldes, 1995). Among several sources of uncertainties, medical expenditure risk accounts for a significant portion of idiosyncratic risks faced by the elderly (Goldman & Maestas, 2013). At the end of life-cycle, individuals are more likely to face catastrophic health risk, and this surge of health risk, which is intrinsically not fully insurable and diversifiable (Gollier, 1997), further promote savings for precautionary motives. A simulation-based study by Palumbo (1999), for instance, found that a significant portion of elderly's precautionary savings, which amounts to nearly 7% of annual consumption at early retirement stage, arises only from uncertainty regarding medical expenses.

Coupled with the aging population of the U.S. and expansion of social insurance benefits targeting elderly, several studies examined the interactions of social safety nets with health-related uncertainty, and the extent to which these interactions affect precautionary saving. In theory, medical expenditure risk and the amount of precautionary saving are conditional upon the availability of insurance against health risk. Thus, additional safety net ought to reduce the uncertainty regarding future medical expenses and the perceived needs for saving (Hubbard et al., 1995). Motivated by this hypothesis, several studies explored whether and to what extent the federal welfare programs, such as Aid to Families with Dependent Children (AFDC, replaced with Temporary Assistance for Needy Families - TANF), Medicaid, Medicare, and Social Security, provided a disincentive to save.[1] For instance, Gruber and Yelowitz (1999) demonstrated that the expansion of Medicaid during the 80's and early 90's lowered wealth holding of eligible households by 17.7%, with more pronounced impacts for the low-income households. The empirical literature generally confirms the presence of precautionary saving motive to cope with health risk (Chou, Liu, & Hammit, 2003; 2006; Chou, Liu, & Huang, 2004; Finkelstein & McKnight, 2008; Powers, 1998), although a few notable studies reported no evidence or contradicting findings (Guariglia & Rossi, 2004; Starr-McCluer, 1996).

This study contributes to the growing literature on precautionary saving motive against medical expenditure risk by examining the impact of Medicare Part D. This study improves on the literature in a number of ways. First, unlike most of the previous studies that explored working-age populations, this study analyzes the savings behavior of the near-elderly and elderly population who are approaching or just reached the age that entitles them to collect retirement benefits. Individuals at this stage of the life-cycle have the most savings and are less likely to rely on labor income to maintain their living standards. This sample selection allows me to better identify the variations in savings by dropping younger wage earners who may face other forms of background uncertainty related to job security or income fluctuation. For instance, there could be unobserved health issues that significantly lowers labor supply or productivity at the workplace while raising uncertainty about future medical expenditures. If medication adherence significantly improves health outcomes, a failure of accounting for such pathway could confound the impact of social insurance benefits and leads to particu-

[1]See, for instance, Hubbard & Judd (1987), Hurst & Ziliak (2006), Levin (1995), Neumark & Powers (1998), and Powers (1998)

larly impoverished results. Second, I exploit the introduction of Medicare Part D in 2006 to estimate the effects of medical expenditure risk on savings, using data from the Health and Retirement Study. This program, taking all the provisions together, represents the largest expansion of an entitlement program since the program's inception in 1965 (Neuman & Cubanski, 2009). The timing of policy implementation, in conjunction with the longitudinal nature of data, allows me to implement a quasi-experimental study that isolates the treatment effect of additional prescription drug coverage. To the best of my knowledge, no extant study has attempted to measure the impact of the Medicare Part D on savings despite the enormous size of the program. Third, the sample of interest is primarily baby boomers - a cohort that historically has the highest savings of all previous cohorts of Americans. Because precautionary motive is the primary reason to save among the boomers (Gist, Wu, & Ford, 1999), they are expected to be more responsive to the exogenous change in health-related uncertainty.

There are several reasons to believe that Medicare Part D relaxed precautionary motive for saving. First, increased access to cholesterol reducers, oral diabetes pills, and cardiovascular drugs may have reduced uncertainty regarding their future health conditions. Despite the lack of clinical evidence that links Medicare Part D to better health outcomes (Basu, Yin, & Alexander, 2010), the improved or regular access to medications could, at least, have reduced the perceptional uncertainty. People who face lower subjective risk would then have a less incentive to self-insure against unforeseen health risk, and this effect of Part D benefits would be more pronounced for those who were skipping medications due to the prohibitive cost of prescription drugs. That is, this study's identification strategy assumes that regular medication intakes, which improves health conditions gradually but slowly, only affect the medical expenditure risk pertaining to future health status, not the current health conditions and labor market outcomes. Second, better access to prescription drugs could slow down aging process, and thus helps maintain workplace productivity. If medication adherence helps preserve health conditions, Part D beneficiaries may want to remain in the labor force longer than before without prescription drug coverage. The delayed retirement would result in extra income and further reduce the precautionary saving motive. This mechanism, however, would work in the opposite direction if Part D enrollees expect a longer living horizon, and hence less likely to leave the labor market.

This study implements a difference-in-difference (DD) framework that estimates the treatment effect of Medicare Part D on savings. The empirical models identify exogenous variation in health risk by comparing individuals older than 65, and thus eligible for the Part D benefits, to a younger group who could not qualify for a drug plan, before and after the implementation of Medicare Part D in 2006. Although this type of pre-post study design attempt to randomize treatment assignment, comparing eligible/ineligible group only gives the intent-to-treat (ITT) effect because adding a drug coverage under Medicare Part D is essentially voluntary. Some individuals who were eligible for Part D benefits could remain uncovered for a variety of reasons. In this case, age-based eligibility condition is not equal to treatment, and hence one cannot consistently estimate the average effects for those eligible and obtained Part D benefits. This issue is addressed by estimating the local average treatment effect (LATE), which captures the (localized) treatment effects among a subpopulation whose drug insurance coverage is changed by Medicare Part D.

Conditioned on a vast array of covariates, having Medicare Part D coverage is associated with approximately 12% decrease in liquid financial wealth, 8% reduction in non-housing financial wealth and total net worth, and 5% and 4.3% increase in nondurable consumption and total household consumption. With extensive robustness checks and placebo tests, these results remain largely unchanged, indicating that changes in savings are driven by a lower medical expenditure risk *per se*, not via its impact on improved health conditions or employment outcomes. The models with year fixed effects indicate that this decrease in precautionary savings is immediate but possibly temporary. The LATE estimates from the instrumental variable (IV) method showed a much greater association between Medicare Part D and savings, further validating my findings from the preferred specifications. Throughout the analysis, I find the evidence that the expansion of prescription drug benefits significantly discouraged private savings.

2.2 Background

2.2.1 Medicare Part D and Health Outcomes

Medicare Part D provides prescription drug coverage through private drug plans approved by the federal government. The program was established as a part of the Medicare Prescription Drug, Improvement, and Modernization Act (MMA) of 2003, with a goal of extending prescription drug coverage to Medicare beneficiaries and making prescription medications more affordable. Before the program went into effect in 2006, many individuals stayed without drug insurance, and thus had limited access to prescription drugs. According to Safran, Neuman, Schoen, & Kitchman (2005), more than one-quarter of senior Americans and one-third of Medicare beneficiaries had no prescription coverage in 2003. Without Medicare Part D, out-of-pocket (OOP) spending on prescription drugs was especially high, with nearly 55% of seniors spending $50 or more every month. Medication adherence, consequently, was low among the uninsured and low-income individuals.

As a result of this health reform, around half of Medicare beneficiaries who had no drug plans before Part D acquired prescription drug coverage in 2006 (Levy & Weir, 2009). The proportion of individuals with no drug insurance reached up to 25.7% in 2003, but then reduced to 7.5% at the end of 2006. Among this 25.7% who had no drug coverages, 63.1% had enrolled in Part D benefits by late 2006 (Safran et al., 2010). This group of individuals showed significantly increased prescription drug use, higher medication adherence, and lower OOP spending. As of January 2008, more than 25 million Medicare beneficiaries were enrolled in Part D prescription drug plans (PDPs), of whom about two-third subscribe to the Part D stand-alone prescription drug plans (Kaiser Family Foundation, 2010). This enrollment figure reached nearly 27.6 million beneficiaries in April 2010.

Individuals ages 65 and older or those under age 65 with permanent disabilities are eligible for Medicare Part A and Part B. Those on Part A or Part B benefits have the option to add prescription drug coverage under the Part D plan. Enrollment in Part D, in this regard, is essentially voluntary, with beneficiaries allowed to choose private insurers and customize their own drug insurance plan. During the initial open enrollment period, beneficiaries can choose to add a stand-alone prescription drug plans (PDPs) that supplement original Medicare coverage, or enroll in the comprehensive plans under Part C known as the Medicare Advantage prescription drug (MA-PD) plans. In either way, beneficiaries pay a separate premium that covers their choice of drug assortment, which ranges from only a few dollars up to over 100 dollars depending on the benefits of selected drug plan. In general, Medicare Part D pays 75% of annual expenses between \$250 and \$2,250 and 95% above \$5,100 for approved prescription drugs, but nothing between \$2,250 and \$5,100 (i.e., donut hole). This coverage gap lies between the initial coverage limit and a yearly limit that represents the catastrophic-coverage threshold. Once beneficiaries spend up to the yearly limit, this coverage gap ends, and the drug plan helps pay for prescription drugs again. Beneficiaries with income below 150% poverty threshold are eligible for the low-income subsidy, which covers some or all of the monthly premium, annual deductible, and drug co-payments.

The economic consequences of Medicare Part D have been studied extensively, and one robust conclusion is that the expansion of Medicare benefits increased enrollees' drug utilization while reducing OOP health care spending (Simoni-Wastila, Zuckerman, Shaffer, Blanchette, & Stuart, 2008). In the first year of Medicare Part D, the monthly drug utilization rose by 5.9-12.8%, despite a 13.1-15.6% decrease in OOP spending among the enrollees (Yin et al., 2008). A subsequent study by Schneeweiss et al. (2009) reported a similar increase in prescription drug use and reduced OOP spending, with the results varying by drug class. These estimates seem rather conservative as Lichtenberg and Sun (2007) found 12.7% increase in prescription drug use and 18.4% decrease in OOP spending among the one-third who were previously uninsured. In Zhang, Donohue, Lave, O'Donnell, and Newhouse

(2009), total monthly drug spending was $41 higher among the beneficiaries who had no drug coverage, but this increase was offset by even more decrease in total medical spending, perhaps due to the improved physical health with prescription drugs.

Despite the evidence showing that medication adherence is critical to improving/maintaining health conditions (Sabate, 2003), the clinical impact of Medicare Part D is is mixed and somewhat inconclusive (Kaestner, Long, & Alexander, 2014). For instance, Hanlon et al. (2013) reported increased access to cholesterol-control pills among the Part D enrollees, with no discernible impact on their cholesterol levels. Kaestner and Khan (2012) found no evidence that the self-rated health and functional disabilities are improved among the Part D beneficiaries. A notable study by Dunn and Shapiro (2015) examined the cardiovascular health of Part D enrollees, and found the evidence that Medicare Part D significantly lowered deaths from cardiovascular disease (CVD). Their estimates indicated that nearly 26,000 individuals were alive in 2007 due primarily to the expansion of prescription drug benefits. Similarly, Huh and Reif (2015) argued that approximately 4.4% decrease in CVD mortality rates is attributable to Medicare Part D. Another study focused on the increased antidepressant use and adherence among Part D enrollees. In a study of American sample, Ayyagari and Shane (2015) examined whether and to what extent Medicare Part D is associated with late-life depression. By analyzing American seniors, they found that about 15% reduction in a CES-D score (i.e., a number of depressive symptoms) and a 21% decrease in the likelihood of experiencing multiple depressive symptoms are due to Medicare Part D.

Another strand of studies reported the decrease in demand for medical services among Part D enrollees. In a study of hospital discharge data from 2005 to 2007, Afendulis, He, Zaslavsky, and Chernew (2011) found 1.2-4.6% decrease in hospitalization rate during 2005 and 2007 is due to the introduction of Medicare Part D. This translates into nearly 42,000 reduction in hospital admissions over the study period. Arguing along related lines, McWilliams, Zaslavsky, and Huskamp (2011) reported a significant drop in nondrug medical spending since 2006, which is more pronounced for those with limited prior drug coverage.

These findings appear to suggest that management of chronic health conditions via prescription medications indeed improved overall health conditions. Hence, the near-elderly and elderly cohorts of individuals would have even less incentive to save for health-related precautionary purposes.

2.2.2 Literature Review: Health Risks and Precautionary Saving

Leland (1968) introduced a two-period model that conceptualizes precautionary demand for saving when individuals face uncertain future income. Since then a voluminous amount of research has made continuous and sustained efforts to find the evidence of precautionary saving motive in response to uncertainty. The literature explored multiple domains of uncertainty such as health risk, business risk, and labor income risk, given the assumption that a decrease (or, increase) in risk reduces (or, raise) private savings (Carroll & Kimball, 2001). Despite this extensive exploration of the issue over the decades, empirical findings have been mostly mixed. When it comes to health risk, the literature supports the argument that facing health risk is associated with greater precautionary savings (Atella, Rosati, & Rossi, 2006; Chou, Liu, & Hammit, 2003; 2006; Chou, Liu, & Huang, 2004; Gruber & Yelowitz, 1999), while a few exceptions such as Guariglia and Rossi (2004) and Yilmazer and Scharff (2014) reported only weak or no association.

Early studies have suggested that uncertainty about future medical spending can affect households' savings behaviors (Hubbard et al., 1995; Kotlikoff, 1986). These studies commonly found that any contributing factor of health risk, such as the expansion of social safety nets, significantly affects the uncertainty about medical expenditures, and thus precautionary savings. A study by Palumbo (1999) found that the risk of medical expenses negatively impacts consumption, which explains why many families dissave more slowly than the prediction from a Life-Cycle Hypothesis (LCH). Starr-McCluer (1996) studied the relationship between wealth holdings and health insurance coverage. By examining data from the Survey of Consumer Finances (SCF), Starr-McCluer found that households with health insurance coverage have accumulated more financial wealth than those who are uninsured. The impact of health insurance was even more pronounced when liquid assets were examined as a proxy for savings. While this result clearly contradicts the standard theory of savings under the uncertainty, Starr-McCluer's findings are not very convincing due to a cross-sectional nature of data and the limited control of unobserved characteristics such as risk tolerance that could simultaneously affect insurance status and savings behaviors. A result similar to Starr-McClue was also reported by Guariglia and Rossi (2004). These authors assumed that the National Health Service (NHS) in Great Britain, which is characterized by poor quality and long waiting time, would encourage individuals to save so that they could purchase health care through private markets not reimbursed by the national plan. Conditioned upon a large set of observables, they found that individuals protected by the NHS are more likely to save, whereas the poor and rural residents save significantly less in response to the NHS. Even after accounting for the endogeneity issues, their findings remained inconsistent with the standard prediction of the LCH. Yilmazer and Scharff (2014) explored the extent to which subjective health risk associates with precautionary savings. Instead of examining insurance coverage, they employed self-rated health status of both husband and wife to capture household-level health risk. The associations between subjective health risk and precautionary savings were mostly not significant regardless of how precautionary wealth is defined. Only wife's health risk were linked to less precautionary savings, but this association was significant only with the liquid portion of precautionary savings.

Although the results above seem not to support the standard theory of saving under uncertainty, a recent study by Hsu (2013) provides a plausible explanation for these contradictions. Hsu, in general, agrees with the literature that the introduction or expansion social insurance programs indeed creates a disincentive to save. However, she argued that the availability of private health insurance such as employer-provided plan discourage the access to social insurance benefits. Without being covered by social insurance and facing unemployment risk, individuals have an incentive to save (i.e., precautionary savings motive) to hedge against losing jobs, and thus losing employer-provided insurance. This conflict between private and social insurance, in turn, reinforces the positive insurance - savings correlation in the standard saving regression model. Hence, without controlling for private insurance, the regression model captures the net saving effect of health insurance which could be positive if the new public insurance is less generous than the previous private plan.

In contrast to these studies, most of the literature on social insurance programs found the precautionary motive for saving to cope with health-related uncertainty. Gruber and Yelowitz (1999) took advantage of the natural experiment created by the expansion of Medicaid in years 1984-1993. According to their estimates, Medicaid expansion lowered asset holdings by approximately 40 cents for each dollar of Medicaid eligibility, which amounts to 18% less saving across the entire population. In a study of 1995 introduction of National Health Insurance (NHI) in Taiwan, Chou et al. (2003) found that the negative effect of NHI on savings ranges from 8.6 to 13.7%. This effect was more pronounced among the younger households and the families at the bottom of savings distribution. This is broadly consistent with Guiso, Jappelli, and Terlizzese (1992), Hubbard et al. (1995), and Kimball (1990). In a subsequent study on Taiwanese evidence, Kuan and Chen (2013) also found the negative impact of NHI on savings, but their finding was opposite to Chou et al. (2003) and (2004) in that the NHI imposed a greater impact on higher income households. They argued that the estimates of effects of social insurance on saving are sensitive to how those with negative net worth are treated in the regression models. While the authors showed that the crowd-out effect of social insurance increases with saving quantile, the mechanism that governs such association is unclear, and also their findings are not in line with a theoretical framework of Hubbard et al. and Kotlikoff (1986).

While the literature found evidence of precautionary saving motive, those findings were limited in that the reform could also produce an income effect. If this is a case, the motive to self-insure against health risk would be better reflected in other (health-related) precautionary behaviors rather than savings. Chou et al. (2006) delved into this issue by reexamining the impact of 1995 Taiwanese reform on the procurement of private insurance and spousal labor-force participation. Their findings confirmed a negative relationship between social insurance program and savings, but not with the purchase of private insurance and the labor force participation of other family members.

2.3 Method

2.3.1 Data Description

The data for this study comes from the 2000-2010 waves of the Health and Retirement Study (HRS). The HRS is a nationally representative, longitudinal survey of adults aged 51 or older, conducted every two years since 1992. The initial HRS consists of two separate cohorts: the original 1992 Health and Retirement Study cohort who was born between 1931 and 1941; and the 1993 Assets and Health Dynamics (AHEAD) cohort whose birth date lies between 1890 and 1923. Since then, the Children of Depression Age cohort (born 1924-1930) and War Baby cohort (born 1924-1930) entered the HRS in 1998. A younger group of individuals born between 1948 and 1953 (Early Baby Boomers) is also included in the survey from 2004 wave. The HRS is an ideal source of data as it includes extensive information on mortality/morbidity outcomes, employment status, household income and wealth as well as individuals' prescription drug coverage status.

In order to define a comparable size of "treatment" and "control" groups, the analytic sample does not include the respondents younger than 60 or older than 70. While Medicare eligibility is granted primarily for those 65 and older, individuals under 65 who have been receiving Social Security Disability Insurance (SSDI) for more than 24 months due to disabilities could also qualify for Medicare. This group of people, at the same time, could collect other benefits such as Social Security and Railroad Retirement program before they turn 65. Because this group may have had experienced serious health conditions and is likely to be on multiple welfare programs, their response to prescription drug benefits would be markedly different from other respondents (Ayyagari & Shane, 2015). Thus, I further restrict the sample by dropping those who received Medicare benefit before 65 due to disabilities.[2]

The final sample for analysis excludes observations with no responses or miscoded values whenever such data points are identified. As a result, the analytic sample is an unbalanced panel comprising 29,191 observations of 10,085 individuals.

2.3.2 Measures of Precautionary Savings

The literature has utilized many different measures of precautionary saving. Some studies relied on liquid wealth as a proxy for household precautionary savings (Engen & Gruber, 2001; Starr-McCluer, 1996), whereas another strand of literature examined less restrictive measures that include housing equity or wealth held in retirement accounts (Benito, 2009; Hurst & Stafford, 2004; Kennickell, Starr-McCluer, & Sunden, 1997; Lusardi, 1998). Although housing equity or real estate wealth is not as liquid as cash equivalents, housing assets constitute a large share of household wealth and became more liquid with the recent development of home equity lines of credit (Kennickell & Lusardi, 2004).

For the purpose of analysis, this study employs three measures of precautionary savings. The first measure defines precautionary savings as liquid wealth divided by permanent income (Lusardi, 1998; Yilmazer & Scharff, 2014). The liquid wealth is defined as the net value of cash equivalents, stocks and mutual funds, bonds and bond funds, and other savings. Following Lusardi (1998), permanent income is constructed by predicting the values from a model that regresses 1998 total household income on individual-level exogenous regressors such as age, gender, race, education background, retirement status, and all possible two-way interactions of these variables. The second measure of savings is the total non-housing wealth divided by permanent income (Kennickell & Lusardi, 2004; Yilmazer & Scharff, 2014). This

[2]Note that the HRS does not provide detailed information on disabilities and how long they have received welfare subsidies. Hence, I use age at interview and a survey response on whether the respondents are covered by federal health insurance program to identify such respondents.

measure expands the liquid wealth by including the value of retirement accounts and non-housing wealth such as IRA, Keogh accounts, vehicles, businesses, and real-estate. Since this study focuses on the elderly, financial assets held in retirement accounts could be of primary importance. The third measure of precautionary savings is total net worth divided by permanent income, which expands the second measure by including housing wealth.

Although there are numerous ways to define household precautionary wealth, neither of those measures perfectly captures the amount of savings specifically attributable to the uncertainty of future. One way to cope with this problem is to examine the responsiveness of consumption, which is typically measured with greater precision in national surveys (Chou et al., 2003; 2004; Kuan & Chen, 2013). While financial well-being has long been measured with income and wealth, these measures are under-reported for those at the bottom of income distribution. It has been argued that consumption is a better measure of long-term living standards than the most widely cited income/wealth-based figures (Meyer & Sullivan, 2003). In this study, if the respondents respond to the lower risk of medical expenses by reducing their savings, these expenditures must be reflected in additional consumption.

The measures of household consumption are drawn from the Consumption and Activities Mail Survey (CAMS - a supplement to HRS), and match-merged with the primary dataset. The first consumption measure includes household expenditures on non-durable goods such as food, gas, clothing, dining out, vacations, tickets to events, and hobbies, which is known to be the most precise estimate of household consumption (Browning & Lusardi, 1996). The second consumption measure is more expansive and includes non-durable consumption as well as spending on durable goods, housing, and transportation. In the analyses, I pay particular attention to the first three savings measures, and then explore the responsiveness of household consumption to confirm the robustness of findings.

2.3.3 Empirical Specification

This study's identification strategy closely follows Ayyagari and Shane (2015) where a difference-in-difference (DD) framework is designed to explore the impact of Part D on depressive symptoms. The quasi-experimental approach evaluates the impact of health reform by comparing the savings of the "treatment" group to the "control" group, before and after the implementation of policy in 2006. As Part D benefit is available to those who qualified for Medicare Part A/B, the influence of prescription drug coverage is identified by comparing savings outcomes of the affected individuals (i.e., persons aged at least 65 years) to those who were not eligible for the benefits (i.e., persons younger than 65), over time relative to when Part D benefits were introduced. Compared to a non-experimental approach, this DD framework ensures that the effect of Part D is not confounded by the unobserved time-varying effects that correlate with the timing of policy implementation and savings outcomes. If T assigns 1 to the treatment and 0 to the control group, and P equals 1 for the observations from 2006 and thereafter and 0 for the earlier periods, the hypothesis can be laid out as follows:

$$\begin{aligned} H : ATE =& \big\{E(Y|T=1,P=1,\mathbf{X}) - E(Y|T=1,P=0,\mathbf{X})\big\} \\ & - \big\{E(Y|T=0,P=1,\mathbf{X}) - E(Y|T=0,P=0,\mathbf{X})\big\} < 0 \end{aligned} \tag{2.1}$$

, where Y is the savings (or, consumption) outcomes and $\mathbf{X}$ is a set of individual-specific covariates. The difference between the two expressions in parentheses isolates the average treatment effect (ATE) of Part D benefits on precautionary savings. Because the groups differ in demographic characteristics, and the observed results could be due to the underlying heterogeneity, the baseline regression model conditions upon individuals' demographic characteristics, socio-economic conditions, and health status. To test the hypothesis, the following regression model is estimated:

$$y_{i,t} = \Psi + \alpha_1 T_{i,t} + \alpha_2 P_t + \alpha_3 (T_{i,t} \cdot P_t) + \mathbf{X'_{i,t}}\xi + \varepsilon_{i,t} \tag{2.2}$$

, where $t \in \{2000, 2002, 2004, 2006, 2008, 2010\}$ indexes survey years; i indexes individuals; $\varepsilon_{i,t}$ is an *i.i.d.* disturbance term; and Ψ, α_1, α_2, α_3, and ξ are parameters to be estimated. The dependent variable is operationalized with one of the three savings outcomes or two consumption measures transformed by a logarithmic function. The individual-level covariates include age, gender, race, education background, marital status, log-transformed family income, health-related variables, and retirement status. All regression models control for census division fixed effects to account for unobserved regional sentiments towards savings or difference in state-level policies. Since the assignments to treatment/control group are random, these covariates should not significantly affect the estimated coefficients of interest, but may increase the precision with which the model is estimated. The parameter α_1 captures the differences between the eligible and non-eligible groups that are constant over time while α_2 captures differences in savings before and after 2006 that remain the same for both eligible and non-eligible groups. The DD estimate of the ATE in equation (2.1) is captured by α_3, which represents the impact of interaction between $T_{i,t}$ and P_t. This interaction term equals 1 if an individual is eligible and affected by the policy since 2006 and 0 otherwise.

$$\begin{aligned} ATE =& \big\{(\Psi + \alpha_1 + \alpha_2 + \alpha_3 + \mathbf{X}'_{\mathbf{i,t}}\xi + \varepsilon_{i,t}) - (\Psi + \alpha_1 + \mathbf{X}'_{\mathbf{i,t}}\xi + \varepsilon_{i,t})\big\} \\ &- \big\{(\Psi + \alpha_2 + \mathbf{X}'_{\mathbf{i,t}}\xi + \varepsilon_{i,t}) - (\Psi + \mathbf{X}'_{\mathbf{i,t}}\xi + \varepsilon_{i,t})\big\} \\ =& \ \alpha_3 \end{aligned} \tag{2.3}$$

As hypothesized, I expect $\widehat{\alpha_3}$ to be negative if the financial support for drug costs decreases medical expenditure risk.

Since the participation in Medicare Part D is voluntary, the ATE in equation (2.1) is essentially the "intent-to-treat" (ITT) effect which could be biased unless all the affected and eligible individuals apply for drug coverage. In case only a portion of individuals opts in, the ITT averages out the impact of policy reform across all respondents which leads to inconsistent estimates. To circumvent this methodological concern, the alternative specification estimates the two-stage instrumental variable (IV) models that implement the same DD model in the first stage regression to identify exogenous variation in the perceived risk of medical expenditures. With this IV strategy, the implementation of Part D is assumed to have a strong exogenous impact on the decision to own prescription drug insurance, and its effect on savings operates only through the changes in insurance ownership and not through other pathways. The binary endogenous variable comes directly from a survey question that asked the ownership status of prescription drug insurance.[3] The first stage model then regresses this measure on the RHS variables in equation (2.2) such that

$$C_{i,t} = \Phi + \beta_1 T_{i,t} + \beta_2 P_t + \beta_3 (T_{i,t} \cdot P_t) + \mathbf{X'_{i,t}}\zeta + \varepsilon_{i,t} \tag{2.4}$$

, where $(T_{i,t} \cdot P_t)$ is an instrument for drug insurance ownership. The second stage model is as follows:

$$y_{i,t} = \Omega + \gamma_1 C_{i,t} + \gamma_2 T_{i,t} + \gamma_3 P_t + \mathbf{X'_{i,t}}\varphi + \widehat{\tau_{i,t}} + \upsilon_{i,t} \tag{2.5}$$

, where $\widehat{\tau}$ is the residual from the first stage regression and $\upsilon_{i,t}$ is *i.i.d.* error of second stage model. This model isolates the effect of insurance ownership changes explained only by Medicare Part D, which is essentially a local average treatment effect (LATE). This model corrects the error due to voluntary participation, and, if correctly specified, supposed to be greater than the ATE. However, this model should be interpreted with a great caution as the LATE is estimated by a two-step model that does not guarantee the unbiasedness of $\widehat{\gamma_1}$. The LATE is only asymptotically consistent and possibly exaggerate the true association if the instrument has any direct impact on savings.

Even when I cluster the standard errors at household level, the unbiasedness of estimates hinges on the assumption that the differences between individuals are random and uncorrelated with other regressors. In case this assumption is violated, the estimates are no longer consistent, and the inferences based on such model could be wrong. As Clark and

[3]Note that the drug insurance ownership in the HRS does not specify whether the prescription drug coverage is provided by Medicare or other private insurance programs. Although this could be at best a noisy proxy, I find a significan increase in the ownership status since 2006 which validates the reliability of measure.

Linzer (2015) argued, this assumption rarely holds in most empirical applications unless there is a *priory* to believe so. To circumvent this issue, I estimate equation (2.2) using fixed effects (FE) model that de-means the regressors to difference out time-invariant individual heterogeneity. The FE model then fits the following equation:

$$y_{i,t} = \Theta + \delta_1 T_{i,t} + \sum_{t=2000}^{2010} \delta_{2,t} \cdot year_t + \sum_{t=2000}^{2010} \delta_{3,t}(T_{i,t} \cdot year_t) + \mathbf{X}'_{\mathbf{i,t}}\vartheta + e_{i,t}, \tag{2.6}$$

, where $year_t$ is a binary variable that equals 1 for the respective survey year and 0 otherwise. If the FE model excludes $year_{2000}$, $year_{2002}$, and $year_{2004}$ as base years and Part D has an expected impact, $\widehat{\delta_{3,t}}$ would be negative and significant for $(T_{i,2006} \cdot year_{2006})$, $(T_{i,2008} \cdot year_{2008})$, or $(T_{i,2010} \cdot year_{2010})$. These estimates would then indicate the difference in precautionary savings between the control and treatment group for each year relative to the reference years. Thus, this specification shows whether the households immediately adjusted their savings in response to Medicare Part D, and whether the impact is temporary or persistent throughout the study periods.

2.4 Results

2.4.1 Descriptive Analysis

The empirical analysis begins with summary statistics in Table 2.1. To better describe sample characteristics, the data is categorized into four groups according to a combination of treatment and eligibility conditions. The table shows that 8,498 observations in the final sample were eligible and affected by Part D benefit, while 7,387 observations were neither eligible nor affected. The sample points are equally dispersed across the categories except not eligible - after 2006 group. Respondents are predominantly non-Hispanic White, the average respondent is 65.4 years old, and more than 40% attained at least some college education. Approximately 70% of households are married, while the proportion of coupled respondents is lower for the eligible and aged groups. I also find that 60% of respondents are female, which seems to support a longer lifespan of women in general. Regarding the retirement status, 67% of eligible respondents considers themselves completely retired, while this proportion reduces to 39% for the non-eligible and thus younger respondents. Consequently, about half of the non-eligible respondents had employer-provided health insurance, which nearly doubles the 25% of the eligible group. Overall, this analytic sample is representative of the US civilian non-institutionalized population at retirement age during the given period (West, Cole, Goodkind, & He, 2014).

Regarding health status, only 6% of respondents believe their health status is poor, and the validity of self-assessment is reaffirmed by the low prevalence of diabetes, cardiovascular disease, and cancer. The mean CES-D score, which denotes the number of depressive symptoms, is 1.27 on a scale of 0 to 8. The CES-D score is significantly higher among the eligible and thus older respondents, supporting that retirement may lead to poor mental health (Dave, Rashad, & Spasojevic, 2006).

The mean liquid wealth adjusted to 2012 dollar values is $19,144 in the full sample and is quite comparable across the non-eligible groups and eligible - before 2006 group. This amount, however, reduces to $15,996 when the sample is limited to the eligible - after 2006 group. The mean financial wealth is $98,272 in the full sample, and a similar pattern is found across the four categories although the relative difference is smaller than liquid wealth. Such pattern is no longer observed as the savings outcome includes housing wealth.

These findings are informative but do not show whether the difference in financial wealth is due to the introduction of Medicare Part D and through which mechanism it disincentives precautionary saving. As discussed in Methods section above, the analysis proceeds by comparing the savings outcomes before and after 2006 while differencing out the variation between eligible and non-eligible groups.

2.4.2 Regression Results: Baseline Specification

Table 2.2, 2.3, and 2.4 show the estimated baseline models for the DD framework with log(liquid wealth/permanent income), log(financial wealth/permanent income), and log(total net wealth/permanent income) as responses. Column (1) of Table 2.2 shows the estimates of ATE in the null model that includes no covariates other than region fixed effects. The interaction between eligibility condition and the post-2006 dummy is negatively associated with the liquid wealth at the 1% significance level. The R^2 is 0.033, indicating that the ATE of Part D itself explains meaningful variation in the liquid wealth. In column (2), adding demographic variables reduces the magnitude of association, but the ATE remains significant at the 5% level. This indicates that the estimate of ATE in column (1) is not due to individuals preference features. Column (3) includes a binary measure of non-government health insurance. Since private health insurance is an important predictor of savings and Part D coverage could substitute for private drug insurance (Hsu, 2013), the impact of Part D benefit cannot be estimated with a great precision without accounting for such factor. In a model with private health insurance, the estimate of ATE is slightly inflated but not much different from column (2). Interpreting the baseline specifications, the introduction of Medicare Part D in 2006 reduced the liquid wealth of eligible households by 15.3%. Evaluated at the sample mean (mean liquid wealth = \$19,144), this effect translates into roughly a \$3,000 decrease in liquid savings. Tables 2.3 and 2.4 show the similar patterns of associations between Medicare Part D and other savings outcomes. For instance, Table 2.3 shows that about 8.1% decrease in the non-housing financial wealth is attributable to Medicare Part D. Evaluated at the sample mean (mean financial wealth = \$98,272), this association is equivalent to the decline in non-housing financial wealth of nearly \$8,000. In Table 2.4, total net worth dropped by 8.3% (about \$16,700 when evaluated at the sample mean) in response to this health reform. These back-of-the-envelope calculations suggest that the effect of additional drug coverage is more pronounced with illiquid savings. Some households might have changed their rates of contributions or withdrawal from retirement savings, or even borrowed against their home equity as their precautionary saving motive relaxes.

As discussed above, clinical evidence found a greater access to prescription drugs controlling cholesterol, diabetes, hypertension, and depression among Part D enrollees. If then, our findings from baseline specifications could be due to the improved physical or mental health, not solely because of reduced medical expenditure risk. If the prescription drug coverage demotivates precautionary savings through its impact on health, the association should be less significant or insignificant when the models account for respondents' health conditions. Table 2.5, 2.6, and 2.7 present the estimated results in which the previous models are conditioned on self-reported health, chronic diseases, and mental health. In Table 2.5, the coefficient estimate on ATE is nearly invariant with self-reported health measures, and still significant at the 5% level. Controlling for chronic conditions and depression score further attenuates the association. Column (4), which is a fully specified model, shows an 11.8% reduction in liquid wealth in response to Part D benefit. Evaluated at the sample mean, this effect amounts to a \$2,300 reduction in liquid savings. Note that this estimate is significantly smaller than the corresponding result in Table 2.2. In Table 2.6, the association is significant at the 10% level only in column (1) and (4), but not significant in (2) and (3). The coefficient estimates do not vary as in Table 2.5 even though the models account for chronic health conditions. This could be because these health measures do not correlate with the association between the ATE and liquid wealth. Again, the ATE of Part D on financial wealth is smaller than its influence on liquid wealth, which further validates our primary findings. Table 2.7 also shows the same pattern and magnitude of associations as in Table 2.6, while the estimates are significant at 5 or 10% level.

Throughout Table 2.8 to 2.10, I account for the retirement status to examine whether the impact of Part D is mediated by employment outcome. For instance, a better control of cholesterol or blood sugar level could have increased productivity at the workplace, and thus could have affected respondents retirement decision. There also might be an opposite pathway that promotes retirement by lowering incentives to work for labor income. Column (2) of Table 2.8, however, shows no significant difference in the estimate of ATE even with a measure of retirement status. This, again, indicates that respondents' retirement decision is not a pathway that the health reform discourages precautionary savings. More importantly, wage earners may have had employer-provided drug insurance, and if such policy reform had no discernible influence on their employment status their savings outcomes should not be responsive to Part D benefit. Column (3) takes this aspect into account by modeling a difference-in-difference-in-difference (DDD) framework which controls a three-way interaction between eligibility condition, post-2006 dummy, and retirement status. The idea is to use the retirement status as a counterfactual, and therefore difference away any difference in savings between the employed and unemployed that has nothing to do with the introduction of Medicare Part D. Column (3) shows a strong negative coefficient estimate on the three-way interaction which further supports my primary findings. This pattern still holds with non-housing financial wealth and total net worth as the response (Table 2.9 and 2.10), although the associations are smaller.

2.4.3 Regression Results: Robustness Checks

In Table 2.11, 2.12, and 2.13, I check the robustness of findings by gradually adding covariates to the models which could have confounded the association between Part D benefit and precautionary savings. First, I account for the number of living children to capture the variation in savings due to bequest motives. Households with strong bequest motives may have a greater incentive to save and retain their wealth regardless of how much they are insured, and thus with bequest motives the impact of additional safety net would be smaller (Kennickell & Lusardi, 2004). The second confounding factor is impatience. Previous studies showed that impatient households are less likely to save for precautionary motives, and this is particularly the case among those at early or very end of life-cycle (Carroll, 1997; Carroll & Samwick, 1998). If then, this could be another important preference feature that might explain between-individual variation in savings. Following the literature, impatience is proxied by respondents' current smoking status. Third, since the measures of savings outcomes include equities such as stocks and stock-oriented mutual funds, I match the data with the S&P 500 monthly index and account for such changes to net out any variation due to average stock market performance. The monthly S&P 500 data is obtained from the FRED Economic Data of Federal Reserve Bank of St. Louis. Fourth, cohort fixed effects are included to control for different tastes towards savings among the individuals characterized by different birth periods (Kennickell & Lusardi, 2004). I binary-code cohorts membership in the HRS and omit AHEAD cohort as a reference group in the regression models. Lastly, I also consider the possibilities that prescription drug coverage manipulates the expectations about future health conditions or perceived longevity risk and, in turn, affects savings outcomes (Kennickell & Lusardi, 2004). This confounding variation is accounted by a measure of subjective survival probability in the HRS. Not surprisingly, none of the potentially confounding factors significantly alter the impact of Medicare Part D on non-housing financial wealth and total net worth.

In Table 2.14, I quantify the association between social safety net and precautionary savings by examining household consumptions. According to the estimation results, about 5% and 4.3% increase in nondurable consumption and total household consumption are attributable to the implementation of Medicare Part D. Evaluated at the sample mean (mean nondurable consumption = $28,400 and mean total consumption = $56,700), these estimates represent about $1,400 increase in annual nondurable consumption and $2,400 rise in total consumption. Note that these estimates are quite comparable to $2,300 decrease in liquid wealth in Table 2.5. Along with the primary findings from the savings models, these results indicate that households with additional safety net spend more while setting aside fewer emergency funds.

Table 2.15 presents the fixed effects estimates of the ATE with difference reference groups. Models in column (1), (3), and (5) omit year 2004 dummy as a reference group, whereas all periods before 2006 are omitted in column (2), (4), and (6). Across all six models, significant associations between Medicare Part D and savings outcomes are observed only in 2006 and 2008, with more pronounced and statistically significant impact in 2006. This could be because the saving-reducing impact of social insurance is only temporary and does not induce permanent changes in savings behavior, or simply due to nearly doubling increase in personal saving rate since 2007.

Finally, I examine the LATE of Medicare Part D in Table 2.16. Column (2), (4), and (6) show the estimates of LATE with each savings outcomes. The 2SLS estimates are all negative and statistically significant, but about two or three times greater than the OLS estimates. This is not of a surprise because the ATE averages out the impact of Part D benefit across the sample regardless of actual changes in the drug insurance ownership. In Table 2.17, I perform the placebo tests by implementing the same identification strategy with different sample selection. I first dropped any respondents older than 65 during the study period, and then created a binary variable that assigns 1 to those between 57 and 64 years of age and 0 otherwise. This variable falsely defines a treatment and control group. Not surprisingly, I do not find any significant impact of the post-2006 dummy regardless of the specification.

2.5 Conclusion

Despite the abundance of prior studies, the evidence of precautionary saving motive to cope with medical expenditure risk has been mixed. The seminal pieces such as Gruber and Yelowitz (1999) and Chou et al. (2003) tested for the precautionary motive by examining changes in savings in response to the introduction or expansion of social insurance benefits. While these studies found a saving-reducing impact of additional safety net, other studies reported only weak or no precautionary motive among particular subpopulations (Guariglia & Rossi, 2004; Yilmazer & Scharff, 2014), or reverse association that contradicts the standard theory of savings under uncertainty (Starr-McCluer, 1996). Moreover, many of these studies utilized identification strategies that were prone to confounding effects or simultaneity, and hence their findings could be due to its impact on employment/retirement outcomes, not because of the reduction in health risk *per se*.

This study exploits the expansion of Medicare benefit in 2006 as a source of exogenous impact on the propensity to save out of precaution. I implement a pre-post study design to identify the variation in savings due to this policy reform, assuming that additional prescription drug coverage proxies for a lower future medical expenditure risk. The findings consistently show the evidence of precautionary saving motive and a negative causal impact of Medicare Part D on savings. In particular, I demonstrate that this lower saving is driven primarily by facing less medical expenditure risk, not via its effect on retirement status or physical/mental health. After controlling for a vast array of confounding covariates, the association between Medicare Part D and lower savings become even more significant irrespective of the definition of precautionary wealth. A robust and relatively novel result is the temporariness of this association. The fixed effects estimates show that Part D's impact was immediate but significant only for the first few years after the reform. The difference-in-difference-in-difference models support the primary findings by demonstrating a stronger association among the retired who are less likely to have employer-provided drug insurance. Throughout the study, the estimates of ATE is comparable to the previous studies such as Chou et al. (2003; 2004) and Gruber and Yelowitz (1997).

Table 2.1: Descriptive Statistics

	Not Eligible Before 2006	Eligible Before 2006	Not Eligible After 2006	Eligible After 2006	Full Sample
Savings outcomes					
Liquid wealth§	$19,399	$20,663	$21,328	$15,996	$19,144
Financial wealth§	$103,250	$95,720	$115,597	$86,703	$98,272
Total net worth§	$194,413	$190,163	$230,056	$206,139	$201,333
Liquid wealth / perm. inc.§	0.25	0.33	0.23	0.22	0.26
Financial wealth / perm. inc.§	1.29	1.58	1.24	1.15	1.32
Total net worth / perm. inc.§	2.62	3.19	2.50	2.78	2.82
Health conditions					
SR health: poor (0,1)	0.04	0.07	0.04	0.07	0.06
SR health: fair (0,1)	0.14	0.18	0.14	0.17	0.16
SR health: good (0,1)	0.32	0.32	0.32	0.34	0.33
SR health: very good (0,1)	0.35	0.31	0.37	0.32	0.33
SR health: excellent (0,1)	0.15	0.12	0.13	0.10	0.12
Diabetes (0,1)	0.14	0.19	0.18	0.24	0.19
Heart problem (0,1)	0.16	0.23	0.17	0.25	0.21
Stroke (0,1)	0.03	0.05	0.04	0.06	0.05
Cancer (0,1)	0.10	0.14	0.12	0.15	0.13
CES-D score (0-8)	1.22	1.36	1.17	1.26	1.27
Socioeconomic covariates					
Age (60-70)	62.0	67.4	62.2	67.6	65.4
Male (0,1)					0.40
Non-Hispanic White (0,1)					0.77
Non-Hispanic Black (0,1)					0.14
Other races (0,1)					0.09
Less than high school (0,1)					0.19
High school graduate (0,1)					0.38
Some college (0,1)					0.21
College graduate (0,1)					0.22
Married (0,1)	0.74	0.69	0.77	0.69	0.71
Single (0,1)	0.26	0.31	0.23	0.31	0.29
Household size (1-18)	2.24	2.13	2.22	2.11	2.16
Retired (0,1)	0.40	0.68	0.38	0.65	0.56
Health insurance (0,1)	0.51	0.27	0.50	0.24	0.35
Household income§	58,342	43,149	62,976	45,569	49,612
Observations	7,387	9,295	4,011	8,498	29,191

Notes: This table presents the summary statistics of analytic sample. The liquid wealth is the net value of non-housing financial wealth, which is a sum of checking acocunts, government and corporate bonds, stocks and stock-oriented mutual funds, and other savings less short-term debts. The financial wealth is the net value of total non-housing wealth, which is a sum of liquid wealth, net value of vehicles, businesses, real estate (not primary residence), and retirement accounts less short-term debts. The total net worth is a sum of financial wealth and net value of primary residence less short-term debts, mortgages, and home loans. All dollar figures are adjusted to 2012 dollars using the Consumer Price Index for all urban consumers (CPI-U). To account for the skewness of dollar amounts, median values are reported for savings outcomes and household income and denoted by §.

Table 2.2: Average Treatment Effect on Liquid Wealth: Baseline Specification

	(1)	(2)	(3)
Dependent Variable:		Log(Liquid Wealth / Permanent Income)	
	OLS	OLS	OLS
Age 65-70	0.041	-0.023	0.046
	(0.047)	(0.047)	(0.047)
Post	0.040	-0.295***	-0.284***
	(0.056)	(0.045)	(0.045)
Age 65-70 × Post	**-0.280*** **	**-0.137** **	**-0.153*** **
	(0.077)	**(0.059)**	**(0.059)**
Age		0.077***	0.076***
		(0.007)	(0.007)
Male		-0.287***	-0.327***
		(0.038)	(0.038)
Non-Hispanic White		1.069***	1.106***
		(0.073)	(0.073)
Non-Hispanic Black		-0.670***	-0.626***
		(0.084)	(0.085)
High school graduate		1.348***	1.291***
		(0.063)	(0.063)
Some college		1.566***	1.506***
		(0.069)	(0.069)
College graduate		1.756***	1.671***
		(0.073)	(0.073)
Married		0.318***	0.351***
		(0.050)	(0.051)
Household size		-0.348***	-0.343***
		(0.017)	(0.017)
Log(HH income)		0.847***	0.837***
		(0.032)	(0.032)
Health insurance			0.255***
			(0.035)
R^2	0.033	0.425	0.427
Observations	27,017	26,590	26,419

Notes: The liquid wealth is the net value of non-housing financial wealth, which is a sum of checking acocunts, government and corporate bonds, stocks and stock-oriented mutual funds, and other savings less short-term debts. The dependent variable is the liquid wealth divided by permanent income, which is then log-transformed for the analysis. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.3: Average Treatment Effect on Financial Wealth: Baseline Specification

	(1)	(2)	(3)
Dependent Variable:	Log(Financial Wealth / Permanent Income)		
	OLS	OLS	OLS
Age 65-70	0.080**	0.016	0.026
	(0.032)	(0.034)	(0.034)
Post	-0.031	-0.197***	-0.192***
	(0.039)	(0.034)	(0.034)
Age 65-70 × Post	**-0.176*** **	**-0.087***	**-0.081***
	(0.053)	**(0.046)**	**(0.046)**
Age		0.044***	0.045***
		(0.005)	(0.005)
Male		-0.162***	-0.171***
		(0.030)	(0.030)
Non-Hispanic White		0.461***	0.487***
		(0.052)	(0.053)
Non-Hispanic Black		-0.550***	-0.543***
		(0.065)	(0.066)
High school graduate		0.629***	0.636***
		(0.045)	(0.046)
Some college		0.736***	0.743***
		(0.051)	(0.051)
College graduate		0.858***	0.857***
		(0.054)	(0.054)
Married		0.546***	0.565***
		(0.040)	(0.041)
Household size		-0.286***	-0.285***
		(0.014)	(0.015)
Log(HH income)		0.599***	0.605***
		(0.023)	(0.025)
Health insurance			0.075***
			(0.028)
R^2	0.021	0.347	0.352
Observations	28,787	28,509	28,395

Notes: The financial wealth is the net value of total non-housing wealth, which is a sum of liquid wealth, net value of vehicles, businesses, real estate (not primary residence), and retirement accounts less short-term debts. The dependent variable is the financial wealth divided by permanent income, which is then log-transformed for the analysis. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.4: Average Treatment Effect on Total Net Worth: Baseline Specification

	(1)	(2)	(3)
Dependent Variable:	Log(Total Net Worth / Permanent Income)		
	OLS	OLS	OLS
Age 65-70	0.161***	0.016	0.018
	(0.023)	(0.026)	(0.026)
Post	0.009	-0.102***	-0.099***
	(0.028)	(0.027)	(0.027)
Age 65-70 × Post	**-0.138*** **	**-0.080** **	**-0.083** **
	(0.039)	**(0.035)**	**(0.036)**
Age		0.051***	0.051***
		(0.004)	(0.004)
Male		-0.213***	-0.214***
		(0.024)	(0.024)
Non-Hispanic White		-0.094**	-0.088**
		(0.043)	(0.043)
Non-Hispanic Black		-0.412***	-0.418***
		(0.052)	(0.052)
High school graduate		0.137***	0.140***
		(0.036)	(0.036)
Some college		0.105***	0.110***
		(0.040)	(0.040)
College graduate		0.111***	0.112***
		(0.041)	(0.041)
Married		0.196***	0.198***
		(0.032)	(0.032)
Household size		-0.114***	-0.112***
		(0.011)	(0.011)
Log(HH income)		0.491***	0.492***
		(0.014)	(0.014)
Health insurance			0.010
			(0.021)
R^2	0.025	0.208	0.210
Observations	29,726	29,464	29,297

Notes: The total net worth is a sum of financial wealth and net value of primary residence less short-term debts, mortgages, and home loans. The dependent variable is the total net worth divided by permanent income, which is then log-transformed for the analysis. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.5: Average Treatment Effect on Liquid Wealth: Adding Health Conditions

	(1)	(2)	(3)	(4)
Dependent Variable:	Log(Liquid Wealth / Permanent Income)			
	OLS	OLS	OLS	OLS
Age 65-70	0.046	0.069	0.053	0.061
	(0.047)	(0.047)	(0.047)	(0.048)
Post	-0.284***	-0.274***	-0.277***	-0.278***
	(0.045)	(0.044)	(0.045)	(0.046)
Age 65-70 × Post	**-0.153*** **	**-0.145** **	**-0.118** **	**-0.118** **
	(0.059)	**(0.058)**	**(0.059)**	**(0.059)**
SR health: fair		0.492***	0.511***	0.436***
		(0.069)	(0.070)	(0.074)
SR health: good		0.951***	0.922***	0.761***
		(0.070)	(0.071)	(0.076)
SR health: very good		1.280***	1.195***	1.008***
		(0.071)	(0.073)	(0.079)
SR health: excellent		1.251***	1.193***	0.973***
		(0.078)	(0.081)	(0.087)
Diabetes			-0.278***	-0.276***
			(0.046)	(0.047)
Heart problem			-0.076*	-0.091**
			(0.043)	(0.043)
Stroke			-0.354***	-0.309***
			(0.069)	(0.073)
Cancer			0.282***	0.272***
			(0.049)	(0.050)
CES-D score				-0.067***
				(0.009)
R^2	0.427	0.441	0.441	0.439
Observations	26,419	26,393	25,845	24,703

Notes: Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.6: Average Treatment Effect on Financial Wealth: Adding Health Conditions

	(1)	(2)	(3)	(4)
Dependent Variable:		Log(Financial Wealth / Permanent Income)		
	OLS	OLS	OLS	OLS
Age 65-70	0.026	0.034	0.034	0.042
	(0.034)	(0.034)	(0.034)	(0.034)
Post	-0.192***	-0.214***	-0.195***	-0.182***
	(0.034)	(0.034)	(0.034)	(0.034)
Age 65-70 × Post	**-0.081***	**-0.045**	**-0.068**	**-0.082***
	(0.046)	**(0.045)**	**(0.045)**	**(0.045)**
SR health: fair		0.477***	0.430***	0.355***
		(0.058)	(0.057)	(0.060)
SR health: good		0.855***	0.760***	0.617***
		(0.057)	(0.057)	(0.061)
SR health: very good		1.145***	1.004***	0.838***
		(0.058)	(0.058)	(0.063)
SR health: excellent		1.214***	1.062***	0.880***
		(0.063)	(0.065)	(0.069)
Diabetes			-0.233***	-0.226***
			(0.035)	(0.036)
Heart problem			-0.071**	-0.083**
			(0.034)	(0.035)
Stroke			-0.370***	-0.309***
			(0.059)	(0.061)
Cancer			0.124***	0.115***
			(0.040)	(0.040)
CES-D				-0.063***
				(0.007)
R^2	0.352	0.375	0.375	0.366
Observations	28,395	28,312	27,682	26,577

Notes: Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.7: Average Treatment Effect on Total Net Worth: Adding Health Conditions

	(1)	(2)	(3)	(4)
Dependent Variable:	Log(Total Net Worth / Permanent Income)			
	OLS	OLS	OLS	OLS
Age	0.018	0.028	0.021	0.026
	(0.026)	(0.026)	(0.026)	(0.027)
Post	-0.099***	-0.094***	-0.098***	-0.085***
	(0.027)	(0.026)	(0.027)	(0.027)
Age 65-70 × Post	**-0.083****	**-0.081****	**-0.068***	**-0.081****
	(0.036)	**(0.035)**	**(0.035)**	**(0.036)**
SR health: fair		0.289***	0.267***	0.218***
		(0.046)	(0.046)	(0.048)
SR health: good		0.467***	0.415***	0.321***
		(0.046)	(0.047)	(0.049)
SR health: very good		0.664***	0.586***	0.479***
		(0.047)	(0.048)	(0.051)
SR health: excellent		0.734***	0.659***	0.542***
		(0.050)	(0.052)	(0.055)
Diabetes			-0.131***	-0.136***
			(0.028)	(0.028)
Heart problem			-0.054**	-0.061**
			(0.027)	(0.027)
Stroke			-0.312***	-0.245***
			(0.050)	(0.051)
Cancer			0.090***	0.084***
			(0.031)	(0.032)
CES-D				-0.044***
				(0.006)
R^2	0.210	0.224	0.230	0.228
Observations	29,297	29,233	28,575	27,425

Notes: Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.8: Average Treatment Effect on Liquid Wealth: DD and DDD Estimates with Employment Outcomes

	(1)	(2)	(3)
Dependent Variable:		Log(Liquid Wealth / Permanent Income)	
	OLS	OLS	OLS
Age 65-70	0.061	0.048	0.103*
	(0.048)	(0.048)	(0.062)
Post	-0.278***	-0.257***	-0.285***
	(0.046)	(0.045)	(0.055)
Age 65-70 × Post	**-0.118****	**-0.123****	0.046
	(0.059)	**(0.058)**	(0.081)
Retired		0.642***	0.758***
		(0.035)	(0.055)
Age 65-70 × Retired			-0.152**
			(0.071)
Post × Retired			0.145*
			(0.087)
Age 65-70 × Post × Retired			**-0.354*****
			(0.113)
R^2	0.439	0.451	0.451
Observations	24,703	24,628	24,637

Notes: Column (1) and (2) present the DD estimates of ATE without or with a binary variable of retirement status. Column (3) presents the DDD estimates that exploits retirement status as a counterfactual outcome. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, heath conditions, and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.9: Average Treatment Effect on Financial Wealth: DD and DDD Estimates with Employment Outcomes

	(1)	(2)	(3)
Dependent Variable:		Log(Financial Wealth / Permanent Income)	
	OLS	OLS	OLS
Age 65-70	0.042	0.023	0.083*
	(0.034)	(0.034)	(0.045)
Post	-0.182***	-0.160***	-0.165***
	(0.034)	(0.034)	(0.042)
Age 65-70 × Post	**-0.082***	**-0.084***	0.039
	(0.045)	**(0.045)**	(0.063)
Retired		0.502***	0.637***
		(0.027)	(0.040)
Age 65-70 × Retired			-0.144***
			(0.053)
Post × Retired			0.033
			(0.064)
Age 65-70 × Post × Retired			**-0.222*****
			(0.085)
R^2	0.366	0.378	0.381
Observations	26,577	26,499	26,530

Notes: Column (1) and (2) present the DD estimates of ATE without or with a binary variable of retirement status. Column (3) presents the DDD estimates that exploits retirement status as a counterfactual outcome. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, heath conditions, and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.10: Average Treatment Effect on Total Net Worth: DD and DDD Estimates with Employment Outcomes

	(1)	(2)	(3)
Dependent Variable:	Log(Total Net Worth / Permanent Income)		
	OLS	OLS	OLS
Age 65-70	0.026	0.011	0.034
	(0.027)	(0.026)	(0.036)
Post	-0.085***	-0.068***	-0.038
	(0.027)	(0.026)	(0.033)
Age 65-70 × Post	**-0.081****	**-0.079****	0.010
	(0.036)	**(0.035)**	(0.050)
Retired		0.401***	0.501***
		(0.021)	(0.032)
Age 65-70 × Retired			-0.068
			(0.042)
Post × Retired			-0.050
			(0.051)
Age 65-70 × Post × Retired			**-0.141****
			(0.068)
R^2	0.228	0.246	0.248
Observations	27,425	27,367	27,399

Notes: Column (1) and (2) present the DD estimates of ATE without or with a binary variable of retirement status. Column (3) presents the DDD estimates that exploits retirement status as a counterfactual outcome. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, heath conditions, and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.11: Average Treatment Effect on Liquid Wealth: Robustness Check

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable:	Log(Liquid Wealth / Permanent Income)						
	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Age 65-70	0.048	0.063	0.045	0.032	0.066	0.072	0.112**
	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)
Post	-0.257***	-0.269***	-0.248***	-0.288***	-0.197***	-0.252***	-0.244***
	(0.045)	(0.045)	(0.044)	(0.045)	(0.050)	(0.045)	(0.051)
Age 65-70 × Post	**-0.123****	**-0.137****	**-0.129****	**-0.133****	**-0.168*****	**-0.153*****	**-0.213*****
	(0.058)	**(0.058)**	**(0.058)**	**(0.058)**	**(0.060)**	**(0.058)**	**(0.060)**
Number of children		-0.122***					-0.123***
		(0.009)					(0.009)
Smoking			-0.236***				-0.203***
			(0.050)				(0.051)
S&P 500 (/100)				0.035***			0.036***
				(0.006)			(0.006)
Cohort: CODA					-0.167		-0.346***
					(0.128)		(0.126)
Cohort: HRS					-0.448***		-0.428***
					(0.106)		(0.101)
Cohort: War Baby					-0.508***		-0.504***
					(0.120)		(0.116)
SSP 80-100 (/10)						-0.016***	-0.016***
						(0.006)	(0.006)
R^2	0.451	0.455	0.454	0.451	0.443	0.422	0.425
Observations	24,628	24,240	24,528	24,624	24,669	23,133	22,750

Notes: AHEAD cohort dummy is omitted as a reference group. SSP denotes the subjective survival probability in which the target age lies between 80-100 depending on the age at interview. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, heath conditions, employment status, and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.12: Average Treatment Effect on Financial Wealth: Robustness Check

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable:	Log(Financial Wealth / Permanent Income)						
	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Age 65-70	0.023	0.032	0.017	0.023	0.023	0.032	0.061*
	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)
Post	-0.160***	-0.183***	-0.169***	-0.189***	-0.146***	-0.160***	-0.197***
	(0.034)	(0.034)	(0.034)	(0.034)	(0.038)	(0.034)	(0.039)
Age 65-70 × Post	**-0.084***	**-0.075***	**-0.078***	**-0.091****	**-0.095****	**-0.092****	**-0.119****
	(0.045)	**(0.045)**	**(0.044)**	**(0.045)**	**(0.046)**	**(0.045)**	**(0.046)**
Number of children		-0.077***					-0.075***
		(0.007)					(0.007)
Smoking			-0.297***				-0.280***
			(0.039)				(0.039)
S&P 500 (/100)				0.036***			0.034***
				(0.004)			(0.005)
Cohort: CODA					-0.316**		-0.427***
					(0.141)		(0.134)
Cohort: HRS					-0.229*		-0.220*
					(0.127)		(0.116)
Cohort: War Baby					-0.247*		-0.232*
					(0.135)		(0.125)
SSP 80-100 (/10)						0.001	-0.001
						(0.004)	(0.004)
R^2	0.378	0.384	0.378	0.380	0.380	0.353	0.362
Observations	26,499	26,094	26,406	26,507	26,525	25,047	24,616

Notes: AHEAD cohort dummy is omitted as a reference group. SSP denotes the subjective survival probability in which the target age lies between 80-100 depending on the age at interview. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, heath conditions, employment status, and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.13: Average Treatment Effect on Total Net Worth: Robustness Check

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable:	Log(Total Net Worth / Permanent Income)						
	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Age 65-70	0.011	0.017	0.014	0.017	0.018	0.016	0.015
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.027)	(0.027)
Post	-0.068***	-0.072***	-0.061**	-0.078***	-0.061**	-0.062**	-0.086***
	(0.026)	(0.027)	(0.026)	(0.027)	(0.029)	(0.026)	(0.031)
Age 65-70 × Post	**-0.079****	**-0.088****	**-0.089****	**-0.086****	**-0.092*****	**-0.089****	**-0.090****
	(0.035)	**(0.035)**	**(0.035)**	**(0.035)**	**(0.036)**	**(0.035)**	**(0.036)**
Number of children		-0.049***					-0.052***
		(0.006)					(0.006)
Smoking			-0.216***				-0.196***
			(0.032)				(0.032)
S&P 500 (/100)				0.016***			0.017***
				(0.003)			(0.004)
Cohort: CODA					0.010		-0.083
					(0.095)		(0.089)
Cohort: HRS					0.016		-0.032
					(0.084)		(0.074)
Cohort: War Baby					0.015		-0.029
					(0.091)		(0.083)
SSP 80-100 (/10)						0.002	0.0001
						(0.003)	(0.003)
R^2	0.246	0.248	0.249	0.247	0.245	0.248	0.257
Observations	27,367	26,955	27,282	27,375	27,357	25,880	25,403

Notes: AHEAD cohort dummy is omitted as a reference group. SSP denotes the subjective survival probability in which the target age lies between 80-100 depending on the age at interview. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, heath conditions, employment status, and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.14: Average Treatment Effect on Household Consumption

	(1)	(2)
Dependent Variable:	Log(Nondurable Consumption)	Log(Total Consumption)
	OLS	OLS
Age 65-70	-0.059**	-0.059**
	(0.025)	(0.026)
Post	-0.093***	-0.091***
	(0.022)	(0.020)
Age 65-70 × Post	**0.050***	**0.043***
	(0.029)	**(0.025)**
SR health: fair	0.052	0.121***
	(0.036)	(0.031)
SR health: good	0.082**	0.182***
	(0.037)	(0.031)
SR health: very good	0.163***	0.279***
	(0.039)	(0.032)
SR health: excellent	0.194***	0.332***
	(0.043)	(0.035)
Diabetes	-0.017	-0.043**
	(0.021)	(0.017)
Heart problem	0.076***	0.038**
	(0.021)	(0.016)
Stroke	-0.011	-0.052*
	(0.037)	(0.031)
Cancer	0.056**	0.078***
	(0.026)	(0.019)
CES-D	0.002	-0.006
	(0.004)	(0.004)
Retired	0.046***	0.027**
	(0.016)	(0.013)
Age	0.005	0.002
	(0.004)	(0.004)
Male	-0.090***	-0.013
	(0.018)	(0.013)
Non-Hispanic White	0.241***	0.214***
	(0.031)	(0.023)
Non-Hispanic Black	0.123***	0.083***
	(0.036)	(0.027)
High school graduate	0.113***	0.170***
	(0.026)	(0.018)
Some college	0.243***	0.304***
	(0.029)	(0.020)
College graduate	0.479***	0.554***
	(0.032)	(0.022)
Married	0.332***	0.354***
	(0.021)	(0.015)
Household size	0.042***	0.029***
	(0.007)	(0.006)
Log(HH income)	0.139***	0.072***
	(0.012)	(0.004)
Health insurance	0.080***	0.082***
	(0.017)	(0.014)
R^2	0.372	0.393
Observations	7,215	7,459

Notes: The nondurable consumption is the sum of household spending on gifts, clothing, charitable contributions, dining out, medications and medical supplies, utilities (heat, water and electricity), food and beverages, health insurance and services, telecommunications, tickets, trips and vacations, personal care items, furnishings, hobbies, sports, housekeeping services and supplies, and yard services and supplies. The total consumption is the sum of all of the consumption in the household, including durable consumption, housing consumption, transportation consumption and nondurable consumption. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.15: Fixed Effects Estimates of Average Treatment Effect on Household Savings

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Log(Liquid Wealth / Perm. Income)		Log(Financial Wealth / Perm. Income)		Log(Total Net Worth / Perm. Income)	
	FE OLS	FE OLS	FE OLS	FE OLS	FE OLS	FE OLS
Age 65-70	0.137***	0.137***	0.066**	0.071***	0.038*	0.029*
	(0.051)	(0.040)	(0.032)	(0.024)	(0.022)	(0.017)
Year 2000	0.138		0.087		-0.032	
	(0.133)		(0.082)		(0.059)	
Year 2002	0.008		-0.020		-0.011	
	(0.072)		(0.044)		(0.033)	
Year 2006	-0.116	-0.019	0.019	0.075**	0.091***	0.088***
	(0.077)	(0.053)	(0.048)	(0.033)	(0.034)	(0.022)
Year 2008	-0.056	0.081	-0.077	0.022	-0.049	-0.070**
	(0.132)	(0.076)	(0.083)	(0.047)	(0.058)	(0.032)
Year 2010	-0.257	-0.080	-0.183	-0.038	-0.185**	-0.227***
	(0.200)	(0.105)	(0.123)	(0.064)	(0.087)	(0.045)
Age 65-70 × Year 2000	-0.043		0.007		0.006	
	(0.069)		(0.044)		(0.031)	
Age 65-70 × Year 2002	0.029		0.012		-0.024	
	(0.057)		(0.035)		(0.026)	
Age 65-70 × Year 2006	**-0.087**	**-0.095**	**-0.096****	**-0.085****	**-0.041**	**-0.049****
	(0.062)	**(0.058)**	**(0.038)**	**(0.036)**	**(0.027)**	**(0.024)**
Age 65-70 × Year 2008	**-0.147***	**-0.135***	**-0.086***	**-0.074***	**0.023**	**0.026**
	(0.075)	**(0.071)**	**(0.047)**	**(0.044)**	**(0.032)**	**(0.030)**
Age 65-70 × Year 2010	**-0.087**	**-0.041**	**-0.015**	**-0.007**	**0.017**	**0.024**
	(0.097)	**(0.091)**	**(0.059)**	**(0.056)**	**(0.042)**	**(0.039)**
R^2	0.025	0.024	0.038	0.037	0.043	0.043
Observations	24,662	24,652	26,547	26,536	27,425	27,390

Notes: This table presents the DD estimates from the fixed effects models for each savings outcomes. The reference group of DD estimates in column (1), (3), and (5) is year 2004 interacted with age 65-70, while in column (2), (4), and (6) all two-way interactions before 2006 are omitted as a reference. Robust standard errors are reported in parentheses. Each regression model includes demographic covariates, heath conditions, employment status, and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.16: Local Average Treatment Effects on Household Savings

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Log(Liquid Wealth / Perm. Income)		Log(Financial Wealth / Perm. Income)		Log(Total Net Worth / Perm. Income)	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
Prescription drug coverage	**-0.209*** **	**-0.697***	**-0.249*** **	**-0.553***	**-0.146*** **	**-0.584*** **
	(0.051)	**(0.414)**	**(0.039)**	**(0.298)**	**(0.031)**	**(0.225)**
Age 65-70	-0.020	-0.022	0.023	0.025	-0.014	-0.011
	(0.048)	(0.055)	(0.034)	(0.041)	(0.026)	(0.032)
Post	-0.320***	-0.280***	-0.195***	-0.172***	-0.111***	-0.073***
	(0.031)	(0.048)	(0.024)	(0.035)	(0.018)	(0.027)
R^2	0.457	0.449	0.389	0.382	0.255	0.236
Observations	19,161	19,161	20,663	20,663	21,355	21,355

Notes: This table presents the estimates of the LATE on household savings. The OLS and 2SLS estimates are reported in column (1), (3), and (5), and column (2), (4), and (6), respectively. The exogenous variation in prescription drug coverage is identified by the introduction of Medicare Part D, which exploits the same DD framework. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, heath conditions, employment status, and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 2.17: Placebo Tests

	(1)	(2)	(3)
Dependent Variable:	Log(Liquid Wealth / Perm. Income)		
	OLS	FE OLS	FE OLS
Age 57-64	0.042	-0.014	-0.030
	(0.053)	(0.067)	(0.046)
Post	-0.181**		
	(0.078)		
Age 57-64 × Post	**-0.117**		
	(0.090)		
Year 2000		-0.002	
		(0.153)	
Year 2002		0.039	
		(0.088)	
Year 2006		0.006	0.003
		(0.110)	(0.086)
Year 2008		0.045	0.066
		(0.176)	(0.121)
Year 2010		-0.246	-0.266*
		(0.257)	(0.160)
Age 57-64 × Year 2000		-0.007	
		(0.075)	
Age 57-64 × Year 2002		-0.074	
		(0.071)	
Age 57-64 × Year 2006		**-0.073**	**-0.049**
		(0.094)	**(0.088)**
Age 57-64 × Year 2008		**-0.083**	**-0.080**
		(0.123)	**(0.119)**
Age 57-64 × Year 2010		**-0.011**	**0.008**
		(0.154)	**(0.155)**
R^2	0.433	0.030	0.031
Observations	19,589	19,613	19,619

Notes: The placebo tests re-fit the DD estimates of ATE using the subsample younger than 65 years of age. Column (2) and (3) shows the fixed effects estimates with different reference group as above. Robust standard errors are reported in parentheses. Each regression model includes demographic covariates, heath conditions, employment status, and Census division dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

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Chapter 3

Essay II: Econometric analysis of cognitive abilities and portfolio choice

3.1 Introduction

The association between cognitive skills and financial decisions at the end of life-cycle have drawn renewed interests, with a general finding that declining cognitive abilities crowd out risky investments (Kezdi & Willis, 2003; McArdle, Smith, & Willis, 2009; Christelis, Jappelli, & Padula, 2010). These studies found that individuals with low cognitive abilities tend to reallocate their financial portfolio towards less information-intensive assets and, in turn, leave the equity market earlier than those with enough cognitive capacity. Such a narrative, at first glance, may seem warranted because individuals with low cognitive skills face much higher transaction and information costs (Haliassos & Bertaut, 1995) and lack ability to manage their investments (Campbell, 2006). For instance, Grinblatt, Keloharju, and Linnainmaa (2011) found that low-IQ investors are less skillful regarding stock trading, and more likely to make cost-incurring transactions. Christelis et al. (2010) found that low cognitive abilities discourage direct stock ownership by increasing perceived information costs related to information-intensive assets. It is then not surprising to find that those with low cognitive skills try to minimize the risk of making suboptimal decisions by clearing risky investments (Agarwal & Mazumder, 2013).

Despite a growing interest in cognitive aging, the impact of declining cognitive abilities on portfolio choice is yet to be fully understood. While a number of studies suggested plausible mechanisms, the effect of cognitive ability on risky investments is theoretically ambiguous, and, to the best of my knowledge, no previous studies explicitly tested through which mechanisms cognitive aging discourages risky investments. Especially missing from the extant literature is the aspect of transition that cognitive aging leads to a less risky portfolio. Faced with information costs, individuals with low cognitive skills could choose to leave the equity market, or stay in the market but hedge the risks by holding stocks indirectly through the managed accounts. That is, the impact of cognitive decline could be limited to a transition across the extensive margin - households moving from owning stocks to not owning stocks, or a rebalancing between existing assets with different risk contents. In either case, the riskiness of portfolio would decrease with cognitive decline as described in the literature. This is of particular importance because ignoring the movement along the extensive margin could significantly understate the impact of cognitive aging on lowering stock ownership. Also, the elderly's welfare outcome would be markedly different depending on which change is more pronounced. Equities always deliver superior returns in the long-term, and thus those households in which the portfolio is reallocated across the intensive margin would achieve higher long-term gains.

In addition, the question of whether declining cognitive ability is causally related to a less risky portfolio has not been answered convincingly. The difficulty of identifying a causal path arises because both risky asset ownership and cognitive aging are influenced by unobserved factors that move along the aging curve. For instance, regular and active participation in the financial market requires a cognitively demanding analysis of investment opportunities, and thus individual investors might be able to delay brain aging by inducing cognitively stimulating lifestyles (Vemuri et al., 2014). Moreover, investment proceeds may be used to purchase additional medical services that helps people stay healthy, and further delay aging process. Such unobserved factors and possible reverse effect, if not adequately controlled, could significantly distorts the relationship between cognitive skills and portfolio choice.

This article adds to the growing literature on the relationship between cognitive aging and portfolio riskiness by revisiting the issue with a novel identification strategy. I focus on two research agendas that have not yet been fully explored. First, I identify the impact of cognitive aging on the intensive margin of stock allocation and extensive margin of stock ownership and examine whether the influence of cognitive aging is limited to a particular investment behavior. Unlike the literature that relied on the separate regression models for portfolio composition and stock ownership, I employ two-part regression models that jointly model a mixture of discrete and continuous outcomes. Second, I use Instrumental Variables (IV) techniques to test whether the causality runs from cognitive aging to portfolio choice.

The empirical strategies build upon the prior studies that model the proportion of financial wealth held in equities as a function of cognitive abilities. Since the response is a proportion that is bounded between 0 and 1, linear regression models are subject to three statistical issues: (a) non-normality of nonzero observations; (b) heteroskedastic variances; and (c) excess zeros. To account for these problems, I first estimate the fractional logit model, which is a generalized linear model with a binomial distribution and a logit link function (Papke & Wooldridge, 1996). This estimator generates more plausible predictions while stabilizing unequal error variances and improving normality. The problem might persists if there is a reason to believe that excess zeros - which is a typical pattern of proportional equity data - are generated by a different data generation process (DGP) from nonzero outcomes. To the best of my knowledge, the majority of previous studies have assumed a normal DGP for both zero and nonzero portfolio makeups, which could bias the estimates. Intuitively, if the impact of cognitive aging is significant only on stock ownership but not on asset allocation, treating the fraction as a single continuous outcome could lead to faulty conclusions. A two-part model circumvents such issues by jointly modeling a binary DGP for stock ownership and a continuous DGP for portfolio allocation.

Despite the extensive analysis in the first stage, it remains unclear whether this relationship is truly causal. More direct and strong inference could be achieved if the exogenous variation in cognitive skills is identified by the instrument that only indirectly affects the risky asset ownership. If cognition indeed causally affects stock investments, the association should be significant even with the variation limited to the exogenous part. To find such instrument, I exploit exogenous variation created by the introduction of Medicare Part D in 2006. This identification strategy is developed from the evidence that a greater access to prescription drugs provided by Part D benefit improved cardiovascular health (Dunn & Shapiro, 2015; Huh & Reif, 2015). Since cardiovascular disease is a significant risk factor of cognitive impairments, it is plausible to assume that Medicare Part D slowed down cognitive aging process (Gelber et al., 2013; Khachaturian et al., 2006). The second instrument exploits the association between late-life depression and cognitive aging. While the clinical mechanism through which depression promotes cognitive loss is unclear (Ganguli, 2009), a growing body of literature documented that the development of memory-related diseases such as dementia and Alzheimers disease is preceded by a clinically severe depression (Panza et al., 2010; Thomas & O'Brien, 2008; Vinkers, Gussekloo, Stek, Westendorp, & van der Mast, 2004). To ensure that the impact of Part D runs indirectly through cognitive decline, my IV model deals with respondents with no college education who are less likely to participate in the equity market in response to lower background health risks (Christelis, Georgarakos, & Sanz-de-Galdeano, 2014). The first stage regression estimates a difference-in-difference (DD) model that evaluates the impact of instruments by comparing the eligible group (i.e., persons at least 65 years old) to the non-eligible group (i.e., persons younger than 65), before and after the introduction in 2006.

This study finds ample evidence that risky asset ownership decreases with cognitive abilities. Throughout the analysis, three clear results stand out. First, cognitive abilities associate with investments in risky assets, and this association is not due to changing preference features such as risk aversion and time preference. The correlation between cognitive abilities and risky investments is robust regardless of the inclusion of confounding factors and modeling assumptions. Second, the impact of declining cognitive abilities is significant only on the extensive margin of stock ownership, not on the intensive margin of portfolio allocation. That is, cognitive aging determines the riskiness of portfolio only through the changes in risky asset ownership - a decision to stay or leave the equity market. Third, staying with a spouse or other family members who can undertake the burden of decision making significantly attenuates the impact of cognitive abilities. This pattern is more pronounced for the females who tend to have lower prior stock ownership than males. Fourth, the cognition-stock ownership correlation is likely to be causal, though this causal interpretation is not generalizable to the entire population.

3.2 Literature Review

Previous studies documented that cognitive abilities are an important predictor of equity market participation and the riskiness of portfolio. In a study of the U.S. population, Kezdi and Willis (2003) found that households' risky asset ownership monotonically increase with IQ score, and this association is more pronounced among a less cognitively impaired group. When the sample is limited to the risky asset owners, the probability of leaving the equity market was lower for the investors with high cognition score. Among those with no risky assets, high cognition score eventually leads to stock ownership before the end of study period. Subsequent work by McArdle et al. (2009) also reported that one's cognitive capability increases the share of risky assets and also promotes wealth accumulation. In their study, about \$20,000 and \$7,000 increase in total household wealth and financial wealth were attributable to high numeracy score. These findings were robust even after netting out the influence of declining health stocks, indicating that this is not merely due to physical aging issues.

This "smarter hold riskier portfolio" narrative is not nonsensical, especially when applied to individual investors facing greater information barriers than professional investors. Without financial advice, individuals with poor cognitive skills may have difficulties in gathering and processing investment information, which makes stockholding particularly costly (Christelis et al., 2010). Especially for the elderly, the cost of keeping up with fast-changing financial products and market conditions would be high, given a gradual loss of cognitive skills. For those who are aware of their cognitive deficits, dealing with information-intensive assets might itself be stressful, and thus would impose an additional emotional costs (Campbell, 2006).

Even for the individuals who already hold risky assets, cognitive aging could erode their ability to make savvy financial decisions in a timely manner. By comparing individual investors, Korniotis and Kumar (2011) found that one's investment performance drops dramatically around the age of 70, which is the approximate age when cognitive decline begins.[1] The investors with poor cognitive skills are less likely to pick good stocks and more likely to make cost-incurring transactions. These shortfalls, in turn, lead to about 3.6% lower investment profit per year than other cognitively intact investors, even before and after accounting for transaction costs. Knowing this link, individuals who have experienced cognitive decline might prefer to rebalance their portfolio away from stocks and towards riskless assets (Browning & Finke, 2015). They may also try to hedge the risks by holding stocks indirectly through professionally managed accounts (Christelis et al., 2010), or by completely leaving equity market (Grinblatt et al., 2011).

Cognitive skills may affect risky asset ownership through its impact on the ability to form accurate predictions about returns and associated financial risks. Since individuals with low cognitive abilities process investment information less efficiently, their expectations about future returns and assessment of financial risks would be less accurate (Andersson, Burks, DeYoung, & Rustichini, 2011; Calvet, Campbell, & Sodini, 2007; Grinblatt et al., 2011). This imprecise prediction would not only lower the quality of financial decisions but also translate into greater uncertainty about returns and risks (Gyllenram, Hanes, & Hellstrom, 2013). The stock owners with low cognitive skills then act upon uncertainties and hence face greater chances to lose in the risky asset market. Those holding no stocks would keep staying away from equity market to avoid additional uncertainty, which is a nature of human behaviors (Gneezy, List, & Wu, 2006).

[1]Korniotis and Kumar also found that investment skills improve with experience. In a series of tests, they found that older investors are less likely to trade their stocks, more likely to diversify a portfolio, and more willing to sell the losing stocks at the end of year. Overall, however, the adverse effects of cognitive aging dominates these benefits from "experience".

In addition to information barriers and participation costs, recent literature suggested that cognitive aging may affect individuals' preference features, and therefore, his willingness to bear financial risks (Bonsang & Dohmen, 2015; Calvet & Sodini, 2014; Dohmen, Falk, Huffman, & Sunde, 2010; Frederick, 2005; Hansen & Villa, 2014). These studies found that low cognitive functioning is systematically linked to less patience, low risk tolerance, and a particular personality trait that makes risky investments less favorable. Since risk averse agents are less likely to hold stocks in the face of entry costs, these findings indicate that cognitive impairment discourages risky investments through its influence on preferences. Benjamin, Brown, and Shapiro (2006), in a study of Chilean sample, found that individuals with quantitative skills exhibit lower risk aversion and patience. In their study, a one standard deviation increase in math score was associated with an 8% greater likelihood of risk-neutral behaviors over small stakes and a 10% higher probability of patient behaviors over short-run trade-offs. In an experimental study of German adults, Dohmen et al. (2010) also found a greater risk-aversion and impatience among the participants with low IQ score. Beauchamp, Cesarini, and Johanesson (2011) observed a similar positive association between risk-taking and IQ among Swedish twins. Burks, Carpenter, Goette, and Rustichini (2009) related better cognitive skills to strategic behavior and perseverance, all traits that may increase profits from risky investments. Frederick (2006) develops a Cognitive Reflection Test (CRT) to measure cognitive ability and shows its relation to time and risk preferences. In general, time and risk preferences are tied strongly to cognitive ability in such a way that low cognition group stays away from risks. Bonsang and Dohmen (2015) reported that cognitive aging explains approximately 85% of the increase in risk aversion at the end of life-cycle. The negative association of willingness to take financial risks with declining cognitive skills seems to remain stable over both short-run and long-run (Burks et al., 2009) or even among the younger sample (Benjamin et al., 2013).

A growing body of literature examined financial literacy and its association with financial behaviors. Overall, the literature has shown that financially knowledgeable consumers are more likely to make sophisticated and informed financial choices, and cognitive skills is an important predictor of financial literacy (Lusardi & Mitchell 2014). Kimball and Shumway (2010) found that investors' sophistication is associated with a greater stockholding, diversified financial portfolios, and less home bias. van Rooij, Lusardi, and Alessie (2011) also found that stock market participation monotonically increases with financial knowledge, and this association is much stronger with advanced financial knowledge related to stock investing. In particular, the relationship between financial knowledge and stock ownership does not disappear in the IV models, showing a causal link from financial knowledge to investment decisions. These studies, however, focused primarily on younger adults and failed to test whether the association is due to high cognitive ability, quantitative skills, or financial knowldge *per se*.

Another stream of research links cognitive aging to psychological bias. Finke, Howe, & Huston (2016) found that financial literacy consistently declines after the 60s, while confidence in financial capability remains constant. This pattern was consistent regardless of stock ownership status, gender, and education level, indicating that a growing overconfidence is more of the natural aspect of aging. As described in the behavioral finance literature, overconfident but less skilled individuals may systematically underestimate the risk involved in financial transactions while showing too much optimism about their ability to pick winning securities (Barber & Odean, 2001; Puri & Robinson 2007). Individuals who become overconfident, in this case, may misperceive financial risks and invest a larger fraction of their savings in risky alternatives (Christellis et al., 2010). In addition to overconfidence, Oechssler, Roider, and Schmitz (2009) found that other psychological biases such as conjunction fallacy, conservatism, and anchoring are more prevalent among those lack cognitive skills. In their study, about 62.6% of the low-cognition group exhibited conjunction fallacy, whereas only 38.3% of the high-cognition group was prone to such bias. Conservatism was also less pronounced for the high-cognition group although no significant difference is found in anchoring tests. Overall, these findings show that low cognitive abilities may itself be the source of behavioral biases.

3.3 Method

3.3.1 Data Description

The primary data comes from the Health and Retirement Study (HRS), a biennial longitudinal study that has surveyed individuals 51 years old and older since 1992. The analytic sample is drawn from 1996 to 2012 waves, when the cognitive skills are surveyed along with socio-economic outcomes. Unlike the previous studies, the sample is not limited to a particular cohort but rather utilize the maximum amount of information.

The HRS is particularly well suited to a study of cognitive aging and economic consequences. First, by combining multiple waves the analytic sample includes nearly 60,000 observations even after removing observations with non-responses. Although these missing values yield an unbalanced panel, most observations show up multiple times during study periods which enables this study to track declining cognitive skills and changes in the portfolio. The longitudinal nature of data also allows implementing a difference-in-difference model and IV method.

Second, the HRS provides the most detailed information on cognitive functioning among the all available studies of elderly. While other surveys such as the Survey of Health, Ageing and Retirement in Europe (SHARE) and Cognitive Economics Study (CogEcon) provide information on cognitive abilities, those cognition measures do not span all difficulty levels from advanced to basic cognitive tasks, and reliability/validity is not fully established. The cognition measures in the HRS, however, expand existing scales, and some of the submodules are preceded by pilot tests to determine the feasibility of survey (see Ofstedal, Fisher, & Herzog, 2005).

Third, about one-third of the respondents have died and left the survey during study periods. Since most cognitive losses emerge at the very end of life-cycle (Korniotis & Kumar,

2011) and stock ownership changes dramatically with death, the study of oldest-old participants provides rich opportunities to explore the extent of cognitive aging and its influence on portfolio choice. A vast array of information on spouse, siblings, and children also show the extent to which family support network complements the loss of cognitive abilities.

3.3.2 Cognitive Abilities

To measure cognitive abilities, this study draws information from the cognitive performance battery, originally designed for the Asset and Health Dynamics Among the Oldest Old (AHEAD) and HRS cohort. The baseline AHEAD/HRS instruments were adapted from the Telephone Interview for Cognitive Status (TICS), which is a specialized test module developed for telephone survey (Brandt, Spencer, & Folstein, 1988). Considering phone-based survey environment, the cognitive performance battery excluded non-verbal cognitive functioning measures such as visual and spatial processing, and focused more on assessing memory, mental intactness, and premorbid intelligence. The test instruments included (a) immediate recall task, (b) delayed recall task, (c)serial 7's test, (d) backward counting from 20, (e) date naming, (f) objects naming, and (g) president/vice-president naming (Herzog & Wallace, 1997). For immediate recall task, the interviewer read a list of 10 specific words to the respondents and asked to recall as many of those words as they could. After answering other survey questions for 5 minutes, the respondents were instructed to recall the phrase previously presented in the immediate recall task (delayed recall task). To assess arithmetic ability and working memory, the survey module further instructed respondents to subtract seven from 100 up to five times (serial 7's test) and count backward ten numbers from 20 to 1 (backward counting from 20). These questions are followed by a task to remember the value from the prior subtraction or counting. The subsequent task asked month, day, year, and day of week, and then counted the number of correct responses (date naming). In the object naming task, the respondents were asked to think of the name of an object such that "*people usually use to cut paper*" and the "*kind of prickly plant that grows in the* *desert*". Respondents were then asked to name the current president and vice president of the United States (president/vice-president naming). Also, the survey provided a 5-category self-assessed memory, ranging from 1 for excellent to 5 for poor memory.

The cognition measures in the HRS can be grouped broadly into three categories: (a) immediate word recall; (b) delayed word recall; and (c) mental status. The RAND version data, which provides cleaned and processed variables of the HRS, defines mental status score as a sum of serial 7s, backwards counting from 20, and object, date, and president/vice-president naming tasks, which ranges from 0 to 15. A total cognition score in RAND data is defined on a scale of 0 to 35 by aggregating immediate word recall score (0-10), delayed word recall score (0-10), and mental status score (0-15). I use this score as the first measure of cognitive abilities in this study.[2] Creating a composite measure of cognitive abilities is in line with Kezdi and Willis (2003) and McArdle at al. (2009) in which a set of cognition indices are developed.

This type of classification, however, is arbitrary and could significantly distort the distribution of cognition by ignoring relative difficulties across the tasks. For instance, some survey instruments that measure a particular domain of cognition could be a major determinant of one's cognitive abilities, while other instruments contribute only a small amount. Assuming that the latent cognitive ability is revealed by survey instruments, I conduct principal factor analysis on seven cognition questions and a 5-category self-reported memory.[3] The cognition index is obtained from the first principal component, which represents the shared variance between all cognition indicators. This first principal component is the weighted average of cognition measures where the weights are chosen to maximize the proportion of the variance

[2]Since this study involves the use of IV strategies, I reduce the dimensionality of responses by creating a single measure that represents one's cognitive ability.

[3]Previous studies, such as van Rooij et al. (2011) and Kramer (2012), conducted factor analysis (FA) and calculated Bartlett score to construct a financial literacy index. Although principal component analysis (PCA) and factor analysis generate essentially similar scores, PCA is more relevant to this study because the interest lies in extracting linear composites of observed cognitive abilities rather than forming a theoretical latent. Note also that FA uses a variety of optimization routines and the results, unlike PCA, depend on the optimization algorithms and starting points of iteration. This creates an additional step of robustness checks, which is obviously unattractive.

of these cognition indicators that can be explained by the first principal component. As could be seen from Table 3.1, a latent cognition index is heavily influenced by the first two recall questions, serial 7's, date naming, and president/vice-president naming, while the impact of object naming, self-reported memory, and counting tasks are relatively small. As the index is bell-shaped and not heavily skewed to a particular direction, I do not log-transform this cognition index and analyze as is (Figure 3.1).

3.3.3 Portfolio Choice

Following Rosen and Wu (2004), I define a net household financial asset as the sum of cash equivalents, bonds, stocks, and other liquid financial assets less debt. The total financial asset is categorized into the following breakdowns: (a) net value of stocks, mutual funds, and investment trusts; (b) value of checking, savings; or money market accounts, (c) value of CD, government savings bonds, and T-bills; (d) net value of bonds and bond funds; and (e) net value of all other savings. As the HRS respondents were instructed to exclude any assets held in "IRA" and "Keogh" accounts, this study's definition of financial wealth represents the total value of the household financial asset outside the retirement account. While the retirees put a significant amount of wealth into their retirement account, this study focus only on the portion that households can control directly and are likely to report with minimum measurement error (Love & Smith, 2010). A measure of particular interest is the proportion of financial wealth held in stock, which divides the net value of stocks, stock mutual funds, and investment trusts by total financial assets as in Rosen and Wu. Following Christelis al. (2010), this study also defines a binary indicator for each asset category, which assigns 1 to those own any stocks or stock mutual funds, and 0 to those with no stocks.[4] These measures allow me to examine whether variation in portfolio allocation is affected by relatively minor adjustments between existing assets or drastic changes in ownership.

[4]Without loss of generality, I assume that category (a) represents information-intensive and risky financial assets that require direct investments.

3.3.4 Empirical Specification

The analysis begins with a time series plot of the portfolio share held in stocks over time (Figure 3.2). Two patterns stand out. First, the share of financial wealth held in equities varies little across time periods. Second, most of the variation, if exists, originates from a movement along the extensive margin - that is, changes in stock ownership. This confirms the previous findings that participation in the equity market follows a hump-shaped curve over the life-cycle, whereas the composition of portfolio remains relatively stable over time. This pattern is not surprising but suggests a possibility that the impact of cognitive skills might be different across the intensive and extensive margins.

Considering the nature of portfolio riskiness, the empirical models are divided into four subcategories: (a) linear regression, (b) fractional logit, (c) two-part model: zero-inflated beta (ZIB) regression, and (d) two-step IV models. With a linear representation of relationships, I first replicate the findings from the literature and demonstrate that this simple linear layout violates Gauss-Markov theorem. In the next step, I estimate the fractional logit models (Papke & Wooldridge, 1996) that corrects heteroskedastic variance and improve the normality of response. While the fractional logit is better suited to handling fractional responses, it also relies on the unrealistic assumption that both zero and nonzero proportions are generated by a single Gaussian distribution. As Figure 3.2 shows, however, individuals' stock ownership pattern does not vary with allocation decisions, indicating the presence of separate data generation process (DGP) for zero and nonzeros. Thus, I extend the analysis by estimating the two-part models. By comparing the estimates obtained from two-part models and fractional logit, I examine whether the impact of cognition is limited to the participation decision or whether both ownership and allocation correlate with cognitive aging. Lastly, I implement the IV models by exploiting the exogenous variation in a recent health reform and late-life depression.

Linear Regression Models

The linear representation of an individual's portfolio choice models the extent to which cognitive skills affect the proportion of financial wealth held in stocks. Assuming $\mathbf{X_{i,t}}$ is a matrix that includes a vector of cognitive ability as well as time-variant and -invariant covariates and year dummies, this study estimates the following form of linear regression model:

$$y_{i,t} = \mathbf{X_{i,t}}\boldsymbol{\beta} + \varepsilon_{i,t} \tag{3.1}$$

, where $\boldsymbol{\beta}$ is a vector of parameters; and $\varepsilon_{i,t}$ is an *i.i.d.* normal error term.[5]

Time-invariant control variables are gender, ethnicity, and education background. Gender is operationalized using a single dummy indicating a female. Education is coded into the following ordinal categories: (a) less than high school; (b) high school graduate; (c) some college or technical school; and (d) college graduate and above. Regarding race and ethnicity, the participants were asked to choose from the following categories: White/Caucasian, Black/African American, and Other, followed by a separate question that asked whether the respondent was Hispanic. I aggregate these two questions and categorize respondents into (a) non-Hispanic White, (b) non-Hispanic Black, (c) Hispanic, and (d) other races. This set of measures is assumed to capture individuals' unobserved time-invariant preference features.

A vector of time-variant covariates includes age, marital status, self-assessed health status, chronic health indicators including diabetes, cancer, stroke, and heart problem, retirement status, private health insurance, and logged household income and total net worth. Age is measured by subtracting year of interviews from the year of birth. To minimize the loss of degrees of freedom, marital status is binary-coded with 1 indicating married and partnered couples, and 0 indicating separated, divorced, widowed, and never married individuals. A set

[5]Throughout the study, I treat the data as a pooled cross section with appropriate controls for time, rather than exploiting the longitudinal nature. This is because the panel is short and unbalanced with significantly different time gaps. All regression models, instead, cluster the standard errors at individual level to account for the correlation between individual-specific characteristics.

of health indicators show whether the respondent has been diagnosed with diabetes, cancer, stroke, and heart problem. Respondents were also asked about their perceived general health status with possible responses (a) excellent, (b) poor, (c) good, (d) very good, and (e) excellent. Self-reported health status might be as important as (self-reported) chronic disease indicators due to it's predictive values and relevance to determining behaviors (Miilunpalo, Vuori, Oja, Pasanen, & Urponen, 1997). Retirement status is assessed directly by the question "*At this time do you consider yourself to be completely retired, partly retired, or not retired at all?*", with possible responses (a) not retired, (b) completely retired, and (c) partly retired. This response is collapsed into a binary variable that assigns 1 to individuals who are completely or partly retired, and 0 to those who are not retired. A measure of private insurance coverage is defined as 1 for those covered by health insurance from a current or previous employer and 0 otherwise. To account for the effect of external market conditions on risk aversion (Guiso, Sapienza, & Zingales, 2013), monthly S&P 500 index is obtained from the FRED Economic Data of Federal Reserve Bank of St. Louis and matched with the data. This measure of stock market conditions, in conjunction with year fixed effects, is expected to net out the variation due to changing economic conditions.

Fractional Logit Models

Since the dependent variable is bounded between 0 and 1, equation (3.1) would yield nonsensical predictions for extreme values of the regressors. More importantly, excess zeros (or ones) is a typical characteristic of proportion data because, as in this case, non-participation in a stock market is zero-coded as if it was censored. Thus, rather than exhibiting a random spread around the zero line, the residuals from a linear model "fan out" across the fitted values. The standard error estimates in equation (3.1) would be biased and inconsistent and parameter estimates would no longer be the most efficient unless a suitable transformation is applied to stabilize error variance.

To circumvent the violations of Gauss-Markov theorem, many empirical studies employed type I tobit model which combines the probit model for binary choice with a linear model for nonzero proportions (Edwards, 2008; Guiso, Jappelli, & Terlizzese, 1996; Rosen & Wu, 2004). However, the estimates obtained from this model are still inconsistent if the proportion (i.e., financial wealth held in stocks) is not normally distributed or excess zeros (or ones) are generated by a separate DGP from nonzero values. More importantly, the proportion data is bounded between 0 and 1 only because data points are not defined outside the $[0, 1]$, not because they are censored. Thus, as Maddala (1991) points out, the censored normal model is inappropriate for modeling proportion data.

Instead, this study estimates a fractional logit model (Papke & Wooldridge, 1996), which is essentially a generalized linear model (GLM) with a binomial distribution and a logit link function. This method transforms the proportion response, $y_{i,t}$, using a logit-type transformation that ensures the predicted proportions are contained within a unit interval. That is, the expected value of $y_{i,t}$ conditional on the covariates is:

$$E(y_{i,t}|\boldsymbol{X_{i,t}}) = \Lambda(\mathbf{X_{i,t}}\boldsymbol{\beta}) \tag{3.2}$$

, where $\Lambda(\cdot)$ is logistic cumulative distribution function. This approach not only confines the predicted values within a unit interval but also stabilize the variance using a log-transformation. Following the methods of McCullagh and Nelder (1989), equation (3.2) is estimated by maximizing the Bernoulli log-likelihood function, given by

$$\ell_{i,t}(\boldsymbol{\beta}) = y_{i,t} \cdot \log[\Lambda(\mathbf{X_{i,t}}\boldsymbol{\beta})] + (1 - y_{i,t}) \cdot \log[1 - \Lambda(\mathbf{X_{i,t}}\boldsymbol{\beta})] \tag{3.3}$$

As the variable of interest is continuous, I report average marginal effects (AME) as in Cameron and Trivedi (2010).

Two-Part Models: Zero-Inflated Beta Regression

While the GLM approach addresses non-normality and unequal variance, both bounded and non-bounded values are assumed to follow normal distribution. This feature of GLM approach is unattractive if the DGP of zero outcomes is significantly different from the DGP of nonzero proportions. It is reasonably likely that certain subpopulations almost always do not hold risky assets due to some unobserved reasons such as a lack of education and health issues. Alternatively, these individuals could rely on stock-oriented retirement accounts or, if they are significantly cognitively impaired, they could no longer have incentives to invest in risky assets. In this context, while the fractional logit properly handles boundary outcomes, it does not allow for an alternative DGP that generates the limit values.

As an alternative approach, I consider the two-part models that allow a different DGP for each discretely and continuously distributed random variables. Among a variety of alternatives, zero-inflated beta (ZIB) model (Cook, Kieschnick, & McCullough, 2008) is employed. The ZIB specification consists of two parts: (a) a logit model for binary outcomes; and (b) a beta regression for nonzero fractional responses. The two-part model is flexible in that it allows for any probability distribution for continuous outcomes and any link function for binary responses. Since the proportion of financial wealth held in stocks does not follow any Gaussian-family distribution, the most suitable DGP for this nonzero responses is the beta distribution. The beta distribution is essentially a two-parameter function that accommodates skewness and bimodality of response (Ferrari & Cribari-Neto, 2004). This distribution is very flexible and fit the bimodality of nonzero outcomes particularly well. Assuming $y_{i,t} \sim Beta(p,q)$ where p and q are shape parameters, I follow the reparameterization of Ferrari and Cribari-Neto to model the following beta distribution:

$$f(y_{i,t}|\mu_{i,t},\phi) = \frac{\Gamma(\phi)}{\Gamma(\mu_{i,t}\phi)\Gamma((1-\mu_{i,t})\phi))} y_{i,t}^{\mu_{i,t}(\phi-1)}(1-y_{i,t})^{(1-\mu_{i,t})(\phi-1)} \tag{3.4}$$

, where $\mu_{i,t} = \frac{p}{p+q}$ and $\phi = p+q$. Then, the first part of ZIB is a binary participation equation which models the probability of holding no stocks. Assuming a logit link, this equation is formulated as follows:

$$f(y_{i,t} = 0|\mathbf{X_{i,t}}) = 1 - \Lambda(\mathbf{X_{i,t}}\boldsymbol{\alpha}) \tag{3.5}$$

For nonzero proportions, the following beta regression is estimated:

$$f(y_{i,t}|\mathbf{X_{i,t}}) = \Lambda(\mathbf{X_{i,t}}\boldsymbol{\alpha})\left[\frac{\Gamma(\phi)}{\Gamma(\mu_{i,t}\phi)\Gamma((1-\mu_{i,t})\phi))} y_{i,t}^{\mu_{i,t}(\phi-1)}(1-y_{i,t})^{(1-\mu_{i,t})(\phi-1)}\right] \tag{3.6}$$

, where parameter $\mu_{i,t}$ is estimated by a linear representation $\mathbf{X_{i,t}}\boldsymbol{\beta}$. If, for instance, the stock market participation is positively associated with cognitive ability, the coefficient estimate in the first part would be significant and negative. Similarly, if the cognition gradient of risky investments is significant on the intensive margin, the coefficient estimate of cognition from beta regression would be significant and positive.

Two-Step IV Models

As discussed above, the effect of cognition on stock holding decision is theoretically ambiguous as it depends on the relative sizes of potentially offsetting effects. Onsets of health conditions could precede cognitive decline while simultaneously influencing the portfolio composition through the manipulation of life-cycle factors. Those who actively trade in the equity market could also experience slower cognitive decline as they are exposed to cognitively stimulating environments. To address this endogeneity problem, I employ a two-stage least squares (2SLS) approach that conditions endogenous cognitive abilities on the strictly exogenous regressor. The instrumental variable (IV) estimator is known to be consistent under the assumption that the instruments are uncorrelated to the error term while significantly influencing the endogenous variable. Thus, the appropriate instrument should cause variation in the outcome variable only indirectly through the variation in the endogenous cognitive abilities. As long as the instrument is excludable from the structural equation, this method allows me to isolate the causal impact of cognition on risky asset ownership.

The identification strategy exploits the introduction of Medicare Part D in 2006, assuming that a better access to prescription drugs slowed down the cognitive aging process. The clinical studies have demonstrated that prescription drugs for managing high cholesterol, diabetes, hypertension and depression effectively delay the onset of dementia or Alzheimer's disease by improving cardiovascular conditions (Gelber et al., 2013; Khachaturian et al., 2006). To achieve identification, I implement a difference-in-difference (DD) framework that evaluates the impact of Part D benefit by comparing the eligible individuals (i.e., persons 65 years old or older) to the non-eligible individuals (i.e., persons younger than 65), before and after the implementation in 2006. Following Ayyagari and Shane (2015), I do not include those who are younger than 65 and enrolled in Medicare due to illness or disability.

I assume that the implementation of Medicare Part D is strictly exogenous and causal in a model. More importantly, I assume that this additional health benefit does not induce any (direct) change in portfolio composition or stock investment. This assumption, however, might seem unrealistic because lower risk of health expenditures due to additional insurance benefit could encourage risky investments. However, a recent study by Christelis et al. (2014) demonstrated that health insurance benefit leads to a greater stockholding only for those with college degrees. Their finding implies that the less educated individuals face significantly higher participation costs, and thus they do not change their stockholding pattern in response to the relaxed background risks. Thus, this study's IV models exclude respondents with at least some amount of college education.

The second instrument in the IV models is depression score, assuming that depression induces progressive cognitive decline over time (Panza et al., 2010; Thomas & O'Brien, 2008; Vinkers et al., 2004). For instance, Barnes, Alexpopoulos, Lopez, Williamson, and Yaffe (2006) found that older adults with depression complain of difficulty in concentrating and remembering and that their processing speed and working memory is indeed low. Some studies have shown that patients with Alzheimers disease and dementia report depression well before they report cognitive difficulties, raising the possibility that depression is a significant risk factor for this disease (Geda et al., 2008; Teng et al., 2008). Following this literature, CES-D score, which shows the number of depressive symptoms, is used to capture respondents' mental health. Consistent with previous studies, a strong association between CES-D score and cognitive ability is expected.

To identify the exogenous variation in cognitive ability, I obtain the predicted values of cognitive score from the first stage regression and then include it in the second stage regression. More specifically,

$$C_{i,t} = \mathbf{I_{i,t}}\boldsymbol{\gamma} + \mathbf{Z_{i,t}}\boldsymbol{\zeta} + e_{i,t} \tag{3.7}$$

, where a vector $\mathbf{I_{i,t}}$ is a vector of two instruments and $\mathbf{Z_{i,t}}$ is a matrix that includes all other covariates. The predicted value is then inserted into the second stage equation, which is a ZIB or logit model depending on the nature of outcome variables.

3.4 Results

3.4.1 Descriptive Analysis

Table 3.2 presents the summary statistics by risky asset ownership. Females make up 58% of the sample, mean age is about 71 years, and 66% of respondents are married. Risky asset ownership is more pronounced among males, non-Hispanic White, and the better-educated. Married couples are more likely to hold risky assets than unmarried respondents, and this difference is significant at the 1% significance level. The share invested in the risky asset is age-invariant, as in the dynamic model of portfolio choice (Merton, 1969). About 38% of risky asset owners report health insurance ownership, which is greater than 30% of non-risky asset holders. This may indicate the substitution of medical expenditure risks and investment risks, or a simple correlation due to high stock market participation among wealthy families.

Median household income and total net worth are, as expected, much higher among those with risky assets.

Most of the financial wealth is held in cash or cash equivalents, which is in line with the expectations from Life-Cycle Hypothesis. The proportion of financial wealth held in checking, savings, and money market accounts is 59.8%, while the risk-free assets including CD, government savings bonds, and T-bills make up 11.8% of financial wealth. That is, nearly 71.6% of financial wealth is held in assets that carry no investment risks. About 19.4% of financial wealth is held in equities such as stocks, mutual funds, and investment trusts. The proportion of respondents that own any stocks or stock equivalents is 34.8%.

Cognition summary score, which aggregates seven cognition scores on each domain, is higher for the risky asset owners. The mean cognition summary score among those who have risky assets is 6.79 on a scale of 0 to 10, which is greater than 6.26 of those with no risky assets. Cognition index, which is the first component from PCA based on the cognition variables, replicates the identical pattern although the difference in cognitive abilities between risky/non-risky asset owners is smaller with cognition index.[6] On each domain of cognitive abilities, this difference is greater on cognitively demanding tasks such as word recall, serial 7's, and vocabulary than less challenging tasks such as date naming and object naming.

Table 3.3 presents the stock holding patterns, risk aversion, financial planning horizon, and health conditions by cognitive abilities. Risk aversion is measured by asking questions based on hypothetical scenarios on income increase and job loss. This survey question categorizes respondents into least risk averse, 3rd. most risk averse, 2nd. most risk averse, and most risk averse. The financial planning horizon is self-reported in 5 categories: (a) next few months; (b) next year; (c) next few years; (d) next 5-10 years; and (e) more than 10 years. The descriptive analysis shows the positive association of both stock holding pattern

[6]Throughout the empirical investigations, I examine the effect of cognitive skills using both measures and establish the robustness of findings. For more intuitive interpretations, both cognition measures are normalized on a scale of 0 to 1 and then re-defined on 0 to 10. That is, in the following regression analysis the estimates on cognition variables show how much risky asset ownership varies with a 10 percentage point increase in cognitive skills.

and risk aversion with cognitive skills and risky investments. Specifically, stock ownership is more prevalent among cognitively intact respondents than the cognitively impaired. The proportion of respondents classified as "most risk averse" is much lower in the upper quartile of cognition distribution. Myopic financial planning is pervasive among those with low cognition score, whereas long-term planning is not significantly associated with high cognition score. These patterns indicate that cognitive aging may vary with preference parameters, and thus the impact of cognition could be due to its effect on risk aversion or planning horizon. The chronic conditions that affect cardiovascular health also vary with cognition scores. Those with diabetes or heart problems also scored low on cognition tests. A high CES-D score, which is a measure of depressive symptoms, is negatively associated with cognition tests which seem to support the recent findings in Christopher and MacDonald (2005) and Joormann and Gotlib (2008).

3.4.2 Primary Regression Results

Table 3.4 and 3.5 present the OLS regression results for the full sample. The first column of Table 3.4 shows the estimated equation of the null model that has no covariates except for year fixed effects and S&P 500 index. A strong positive correlation indicates that about 3.33 percentage point decrease in the share of risky assets is attributable to 10 percentage point decrease in cognition summary score.[7] The model in column (2) includes demographic characteristics to account for respondent's preferences. With demographic variables controlled, the parameter estimate on cognitive ability reduces to 0.016 but remains significant at the 1% level. Intuitively, the coefficient on age absorbs some of the variation in the investment behavior due to the movement along the life-cycle and aging curve. As in descriptive analysis, the family portfolio is riskier among the educated and married, and less risky among Black and Hispanic respondents. Accounting for family economic conditions, retirement status, and insurance coverage further reduces the dividend of cognition. The remaining

[7] The interpretation of estimates considers a consistent decline in cognitive skills among respondents.

question is whether the effect of cognitive skills would still be significant after accounting for health-related variables. For instance, cognitive impairments could be the outcome of chronic conditions such as cardiovascular disease, kidney disease, clinically severe depression, brain tumors, or stroke (Panza et al., 2010; Thomas & O'Brien, 2008; Tucha, Smely, Preier, & Lange, 2000; Vinkers et al., 2004; Vogels, Scheltens, Schroeder-Tanka, & Weinstein, 2007), and thus the first three columns could capture the spurious correlation due to physical health. More importantly, since individuals with a chronic illness tend to stay away from risky investment options (Fan & Zhao, 2009; Rosen & Wu, 2004), accounting for physical health indicators may increase the precision with which the model is estimated. In column (4), the indicators of diabetes, cancer, stroke, and heart problem, as well as 5-category self-reported health status are added to the model. With health measures being controlled, the estimate on cognition is not significantly attenuated, indicating that the positive association between cognitive capability and risky investments is not mediated through one's physical conditions. The preferred specification in column (4) shows that a 10 percentage point decrease in cognition summary score lower the proportion of risky assets by 0.96 percentage point. This association is quantitatively meaningful because, evaluated at sample means of the value of stocks and financial assets and holding financial assets fixed, a 10 percentage point decline in cognitive ability implies a decrease in stocks by $1,800. Table 3.5 replicates a similar pattern with cognition index which measures the shared variance of cognition variables. The parameter estimates on cognition are significant at the 1% level, and the standard error estimates remain stable across four regression models. The full model in column (4) shows that about 0.98 percentage point reduction in the share of stocks is attributable to a 10 percentage point decrease in the cognition index. Note that this association is slightly larger than a corresponding estimate in Table 3.4. This difference between Table 3.4 and 3.5 may indicate that cognition index measures cognitive abilities with greater precision, and thus the associations are less downward biased.

Table 3.6 shows the estimation results of fractional logit and ZIB regression models. Column (1) and (3) re-fit the model in column (4) of Table 3.4 and Table 3.5, respectively. Column (2) and (4) present the average marginal effects (AME) calculated as in Cameron and Trivedi (2010). The logit estimate shows that a 10 percentage point decrease in cognition summary score and cognition index is associated with 0.73 and 0.82 percentage point less proportion of stocks, respectively. These estimates are about 20% smaller than the estimates from OLS. Panel B shows the estimation results from the ZIB regression, which separates the variation in proportion due to the binary DGP (i.e., stock ownership) from proportion DGP (i.e., the share of stocks). Interestingly, the association of cognitive skills with the response is no longer significant in a proportion model, regardless of the cognition measure used. The association is negative and significant at the 1% in a zeroinflate model, where the response is 1 for zeros and 0 for nonzero proportions. This shows that the positive estimates on cognition from the OLS and fractional logit are due primarily to the changes in stock ownership status (i.e., stock market participation), not due to portfolio allocations. According to the ZIB models, about 1.35 and 1.54 percentage point decrease in the likelihood of stock ownership is due to a 10 percentage point reduction in cognition summary score and cognition index, respectively.

As discussed, cognition itself is a latent construct whose actual value is unknown, and thus, the estimates on cognition are likely to be downward biased. If then, the parameter estimates presented so far should be understood as a lower bound of the true relationships. To correct this attenuation bias, I exploit the longitudinal nature of data which shows observations of each respondent over multiple time periods. Assuming that measurement error is uncorrelated over time, I re-fit the models in Table 3.6 with the lagged cognition score as an instrument (Griliches & Hausman, 1986). That is, the variation in the cognition score is isolated to the portion explained by the score in the previous period. This procedure is designed to capture only the systematic component in cognitive abilities, rather than temporary fluctuations due to measurement errors. Overall, the estimates in Table 3.7 are 30-40%

greater than those in Table 3.6. For instance, the marginal effect estimates of ZIB model in column (2) shows that about 2 percentage point decrease in stock ownership is associated with a 10 percentage point lower cognitive skills.

3.4.3 Testing Causality

Despite the extensive analysis, previous analyses do not show whether the causality runs from cognition to risky investments. It could be the case that the associations are driven by unobserved factors that correlate with both cognition and risky investments, or capital gains from risky investments improve cognitive health. To circumvent such endogeneity issues, I exploit the introduction of Medicare Part D in 2006 and depression score to identify the exogenous variations in cognitive abilities. The first stage regression models a difference-in-difference (DD) framework that separates the net impact of Medicare Part D on cognition. The second instrument is the depression score, exploiting clinical evidence that severe depressive symptoms impair cognitive abilities (Christopher & MacDonald, 2005; Joormann & Gotlib, 2008). That is, the first stage equation regresses a cognition score on the average treatment effect (ATE) of Medicare Part D and depression score, conditioned upon the same set of covariates. The predicted cognition score is then inserted into the second stage regression to get a consistent estimate of cognitive ability.

The first stage results are reported in Table 3.8. In both models, cognition scores are negatively associated with CES-D score (i.e., the number of depressive symptoms) and positively correlated to the ATE of Medicare Part D. The Part D benefit increased cognition summary score and cognition index by 2.19 and 1.23 percentage point, respectively. One point increase in CES-D score on a scale of 0 to 8 reduces cognitive abilities approximately by 0.55 percentage point. Considering the impact of Part D on depression, this may show that prescription drug coverage helps maintain cognitive abilities through its impact on mental health.

Table 3.9 shows the second stage results of IV models. In panel A, two-stage least squares are estimated by the canned STATA commands that report a variety of test statistics. For both models, the parameter estimates are approximately three times the original OLS estimates without instruments. The test statistics indicate that the first stage equation is neither underidentified nor weakly identified, and the instruments are uncorrelated with the error term. Panel B shows that a 10 percentage point decrease in cognition summary score and cognition index leads to a portfolio with 3.33 and 3.57 percentage point fewer stocks. Evaluated at sample means of the value of stocks and financial assets and holding financial assets fixed, this translates into a decrease in stocks by \$6,400. Results in panel C demonstrate that the causality runs from cognitive abilities to lower stock ownership, but not to a rebalancing of the portfolio away from stocks. About 5.4 percentage point decrease in stock ownership is due to a 10 percentage point reduction in cognition skills.

Cognitive aging is a long-term and gradual process, and individuals may not be fully aware of declining cognitive skills. If it takes a time to recognize mild cognitive impairment, the association of cognition with risky investments would be greater with the lagged cognition measures. In Table 3.10, I test this argument by regressing risky asset allocation and ownership on the lagged cognition measures. The equality of coefficients estimates is tested in each pair of regression models. Throughout the t-tests, I fail to reject the null hypothesis of no difference at the 10% significance level. It seems people who lost cognitive abilities immediately perceive the information costs and adjust their investment decisions accordingly.

In Table 3.11 and 3.12, I examine whether family support network moderates the effect of cognitive aging on stock holdings. I assume that those with a spouse or children are less likely to exit equity market because cognitively demanding investment decisions can be undertaken by cognitively intact family members. This hypothesis is evaluated by estimating a binary choice model of stock ownership with an interaction between cognitive ability and family support network. The first three equations regress a binary variable of stock ownership, while the next three consider a more expansive measure that includes bonds. Panel A employs marital status dummy, which assigns 1 to the married couples and 0 to other respondents. This measure, however, could be a noisy measure of family support network because some of the respondents receive an informal care from children or siblings. Therefore, the second dummy variable employed in panel B captures whether the number of people living in the household is greater than one or not. Two clear results stand out. First, family support network reduces the association between cognitive capability and stock ownership or risky asset ownership. Second, this moderating effect of family support network is more pronounced for females who are less likely to be a financial respondent (financial decision-maker). When the separate regression models are estimated, the moderating impact of family support is observed only in female models. This further provides indirect evidence that cognitive functioning is a significant predictor of risky investments.

3.4.4 Testing Mechanism

Despite a strong evidence of a causal effect, the mechanism through which cognitive aging crowds out risky investments remains unclear. Among several alternative explanations, a growing body of literature paid attention to time-varying preferences along the aging curve. For instance, a seminal work by Dohmen et al. (2010) found that low-IQ investors are more risk averse in the lottery experiment and impatient in the intertemporal choice experiment. Bonsang and Dohmen (2015) demonstrated that about 85% change in risk attitude at the end of life-cycle is attributable to cognitive aging. Hansen and Villa (2014) implied that this late-life increase in risk aversion might be a pathway that cognitive aging leads to the exit from the equity market. In Table 3.12, I test these possibilities by testing whether and to what extent the preference parameters, such as risk aversion and time preference, moderate the effect of cognitive abilities. Risk aversion is derived from a 4-category hypothetical income gamble questions (Barsky, Juster, Kimball, & Shapiro, 1997), and time preference is based on the self-reported financial planning horizon in the HRS. Column (1) and (3) controls for the measures of risk aversion and time preference, respectively, and column (2) and (4) examine the moderation effects. In column (1) and (2), I find evidence that a long-term financial planning is associated with higher stock ownership, but time preference is not a channel through which cognitive skills affect stock ownership. Column (3) adds risk aversion to the full model and re-fit the regression equation. The effect of cognition is inflated, but the difference is trivial and not statistically significant. The estimates in column (4) show that risk aversion does not significantly attenuate the correlation between cognitive abilities and stock ownership. In column (5), I control for both financial planning horizon and risk aversion but find no significant difference in the estimate of cognitive skills. Overall, Table 3.12 do not provide evidence that cognitive functioning affects risky investments through its impact on preference parameters.

In Table 3.13, I further examine whether a particular domain of cognitive skills are more strongly associated with stock ownership. In column (1) and (3), I find evidence that one's stock ownership varies with his/her episodic memory and mental status score, but not with their perception of cognitive abilities. Column (2) and (4) shows that stock ownership is positively associated with immediate word recall, serial 7's, and president/vice-president naming, but negatively associated with date naming. These results, however, do not seem to show any meaningful pattern because other non-significant skills also capture similar domain of cognitive abilities. Moreover, these results are likely driven by high multicollinearity between cognition variables, and hence the effect of each cognition domain cannot be estimated with great precision.

3.5 Conclusion

In this study, I revisited the association between cognitive skills and risky investments with a particular focus on the causality and mechanisms through which cognitive aging reduces the riskiness of portfolio. The estimation results show that a significant correlation between cognition skills and risky investments is mostly due to a transition across the extensive margin, i.e., cognitively impaired individuals exiting the stock market. I also found that this effect is significantly weaker among people with a family support network, i.e., those who can share the burden of cognitively demanding investment decisions with family members. Throughout the studies, these associations remain significant even after accounting for risk aversion and time preference. This supports the non-preference driven explanations of Calvet et al. (2007) and Grinblatt et al. (2011) that cognitive ability does not work through its effect upon preferences. More importantly, I find that the causality runs from declining cognitive abilities to lower stock ownership among those with less-than-college education. Across the empirical models, the associations are not only statistically significant but also meaningful in magnitude.

While this study contributes to the literature in several ways, the following limitations should be emphasized alongside these findings. First, the measure of stock ownership employed in this study does not separate direct investments in stocks from indirect investments through mutual funds. As argued in Christelis et al. (2010), stocks owned through managed investment accounts are arguably less information-intensive because professional managers take care of cognitively demanding investment decisions. If a lack of ability to process investment information indeed reduces stock ownership, the association of cognitive abilities with risky investments should be significantly greater with direct investments. With a measure that does not separate these two different investment vehicles, the impact of cognition could be estimated with errors.

Second, cognition itself is a latent construct and measured with errors in survey data. In regression context, this measurement error downward biases the estimates on cognitive abilities, and also biases all other parameters in the model unless they are uncorrelated with cognition. Using a lag of cognition score as an instrument is proposed to accounts for attenuation bias (Griliches & Hausman, 1986), but the validity of this method hinges heavily on the assumption that measurement errors are uncorrelated over time. This approach also leads to a particular sample selection that excludes relatively younger respondents who showed up the survey only once. More importantly, the IV estimates are not necessarily unbiased and could be inflated if a lagged cognitive abilities significantly correlate with stock ownership.

Third, this study failed to account for numeracy and financial literacy which seem to associate with stock ownership. While numeracy and financial literacy are surveyed in the first few waves of the HRS, more general questions on cognition were not presented in those early waves. In general, financial literacy is believed to be a function of cognitive skills, and thus greater stock holdings among the financially literate could be due to their superior cognitive skills (Lusardi & Mitchell, 2014). For instance, van Rooij et al. (2011) found that education background and IQ are no longer significant predictors of stock market participation once the model accounts for financial literacy. According to their findings, the effect of IQ and education, to a large extent, works through financial literacy. This aspect adds additional complexity to an understanding of mechanism because the association between cognition and stock ownership could be due to cognitive aging *per se* or its impact on lowering financial literacy. This question is worthy of further investigation for more nuanced understanding of mechanism.

Fourth, in order to remove any direct impact of Medicare Part D on stock ownership, the IV models are estimated on the limited sample that excludes college graduates (Christelis et al., 2014). This sample selection is crucial to find a proper identification strategy because social insurance programs can promote stock market participation by reducing background health risk (Cardak & Wilkins, 2009). Unfortunately, my findings from this approach are not generalizable to the better-educated individuals. Since the better-educated and wealthier families may seek financial advice as they lose cognitive skills, the documented effects could be much weaker in the full sample, or the causality could no longer run from cognition to stock ownership.

Fifth, the analytic sample is an unbalanced panel due to missing responses in cognition module. Therefore, I could not exploit the longitudinal nature of data to difference out the impact of time-invariant unobservables. Since the research questions link declining cognitive skills to stock ownership, time-invariant heterogeneity could be better controlled in the fixed effects models.

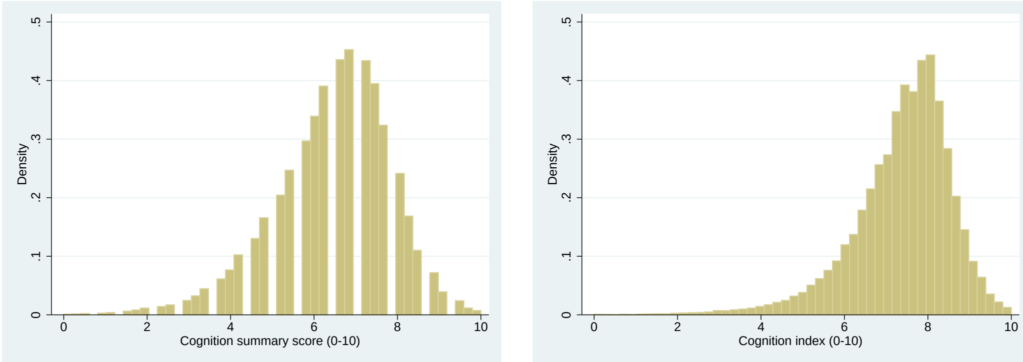

Figure 3.1: Histogram of Cognition Scores

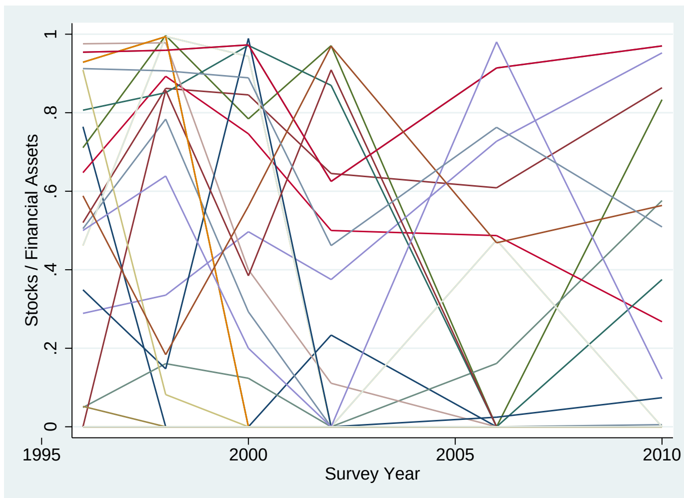

Figure 3.2: Time Series Plots of (Stocks/Financial Assets)

Table 3.1: Principal Components of Cognition Measures, 1996-2012

Variables	1st. component	2nd. component
Immediate word recall (0-10)	0.485	-0.445
Delayed word recall (0-10)	0.480	-0.456
Serial 7's (0-5)	0.360	0.227
Backwards counting (0-2)	0.219	0.488
Date naming (0-4)	0.337	0.236
Object naming (0-2)	0.288	0.324
President/vice-president naming (0-2)	0.331	0.338
SR memory $\geq$ Good (0-1)	0.224	-0.173
Eigenvalue	2.607	1.066
Cronbach's α: 0.656		

Table 3.2: Descriptive Statistics

	Hold No Risky Assets	Hold Risky Assets	Full Sample
Portfolio composition			
Cash / Financial wealth (%)			59.8
Risk-free assets / Financial wealth (%)			11.8
Bonds / Financial wealth (%)			2.3
Stocks / Financial wealth (%)			19.4
Other savings / Financial wealth (%)			6.6
Hold cash (%)			97.2
Hold risk-free assets (%)			29.0
Hold bonds (%)			8.9
Hold stocks (%)			34.8
Hold other savings (%)			17.5
Cognitive abilities			
Cognition summary score (0-10)	6.26	6.79	6.45
Cognition index (0-10)	7.23	7.68	7.39
Immediate word recall (0-10)	5.20	5.65	5.36
Delayed word recall (0-10)	4.09	4.59	4.27
Serial 7's (0-5)	3.40	4.00	3.61
Backwards counting (0-2)	1.89	1.93	1.90
Date naming (0-4)	3.73	3.78	3.75
Object naming (0-2)	1.91	1.96	1.93
President/vice-president naming (0-2)	1.70	1.83	1.75
Socioeconomic covariates			
Age of respondent	70.4	70.9	70.6
Female (0,1)	0.59	0.54	0.58
Non-Hispanic White (0,1)	0.76	0.93	0.82
Non-Hispanic Black (0,1)	0.14	0.04	0.10
Hispanic (0,1)	0.23	0.19	0.23
Other races (0,1)	0.02	0.02	0.02
Less than high school (0,1)	0.25	0.08	0.19
High school graduate (0,1)	0.40	0.33	0.38
Some college (0,1)	0.21	0.25	0.22
College graduate (0,1)	0.14	0.34	0.21
Married (0,1)	0.61	0.74	0.66
Health insurance (0,1)	0.27	0.35	0.30
Retired (0,1)	0.67	0.68	0.67
Household income§	$34,563	$61,653	$42,702
Total net worth§	$143,967	$556,923	$238,950
Observations	54,538	29,110	83,648

Notes: This table presents the summary statistics of analytic sample. Our measure of cash and risk-free assets represent the value of checking, savings, and money market accounts, and the value of CD, government savings bonds, and T-bills, respectively. I define bonds as the value of bonds and bond funds, and stocks as the value of stocks, mutual funds, and investment trusts. Financial wealth is the sum of cash, risk-free assets, bonds, stocks, and others. Total net worth is defined as the sum of financial wealth and net value of primary residence less short-term debts, mortgages, and home loans. Cognition summary score is the sum of seven cognition test scores and cognition index is the first principal component. For intuitive interpretations in regression context, both cognition measures are normalized on a scale of 0 to 1 and then re-defined on 0 to 100. All dollar figures are adjusted to 2012 dollars using the Consumer Price Index for all urban consumers (CPI-U). The median values are reported for income and wealth measures and denoted by §.

Table 3.3: Descriptive Statistics by Cognitive Abilities

	Cognition Score 1st. Quartile	Cognition Score 2nd. Quartile	Cognition Score 3rd. Quartile	Cognitive Score 4th. Quartile
Stocks / Financial wealth (%)	11.8	17.6	22.2	26.0
Hold stocks (%)	21.2	31.8	39.6	46.0
Risk aversion: least risk averse (%)	12.5	10.9	13.7	14.5
Risk aversion: 3rd. most risk averse (%)	8.6	10.9	8.5	9.3
Risk aversion: 2nd. most risk averse (%)	12.2	14.5	15.8	19.9
Risk aversion: most risk averse (%)	66.7	63.7	62.0	56.3
Planning horizon: next few months (%)	18.5	16.5	12.5	11.0
Planning horizon: next year (%)	10.6	10.4	9.2	8.5
Planning horizon: next few years (%)	25.3	25.3	24.4	24.6
Planning horizon: next 5-10 years (%)	31.3	35.6	38.8	39.5
Planning horizon: $>$ 10 years (%)	14.2	12.2	15.2	16.4
Health conditions				
Diabetes (%)	18.3	12.4	10.1	7.0
Cancer (%)	8.3	8.6	7.2	7.8
Stroke (%)	6.2	3.9	2.3	1.6
Heart problem (%)	19.5	17.0	13.5	9.9
CES-D score(0-8)	1.90	1.34	1.16	1.03

Table 3.4: The Effect of Cognitive Abilities on Risky Asset Allocation: Cognition Summary Score

	(1)	(2)	(3)	(4)
Dependent Variable:		Stocks / FA		
	OLS	OLS	OLS	OLS
Cognition summary score	**0.0333*****	**0.0155*****	**0.0112*****	**0.0096*****
	(0.0011)	**(0.0012)**	**(0.0012)**	**(0.0012)**
SR health: fair				0.0058
				(0.0048)
SR health: good				0.0134***
				(0.0051)
SR health: very good				0.0386***
				(0.0056)
SR health: excellent				0.0432***
				(0.0068)
Diabetes				-0.0099**
				(0.0042)
Cancer				0.0073
				(0.0048)
Stroke				-0.0047
				(0.0062)
Heart problem				-0.0050
				(0.0040)
Health insurance			0.0107***	0.0103***
			(0.0037)	(0.0037)
Retired			0.0344***	0.0395***
			(0.0038)	(0.0038)
Log(HH income)			0.0279***	0.0270***
			(0.0015)	(0.0015)
Log(Total net worth)			0.0107***	0.0103***
			(0.0003)	(0.0003)
Age		-0.0002	-0.0037***	-0.0035***
		(0.0013)	(0.0013)	(0.0013)
Age*Age		0.00002**	0.00004***	0.00004***
		(0.00001)	(0.00001)	(0.00001)
Female		-0.0037	-0.0018	-0.0037
		(0.0040)	(0.0039)	(0.0039)
Non-Hispanic White		0.0898***	0.0639***	0.0611***
		(0.0056)	(0.0055)	(0.0056)
Non-Hispanic Black		-0.0119**	-0.0141**	-0.0138**
		(0.0060)	(0.0059)	(0.0060)
Other races		0.0297**	0.0226*	0.0221*
		(0.0129)	(0.0121)	(0.0120)
High school graduate		0.0610***	0.0450***	0.0425***
		(0.0045)	(0.0044)	(0.0044)
Some college		0.1145***	0.0901***	0.0866***
		(0.0056)	(0.0055)	(0.0055)
College graduate		0.2040***	0.1632***	0.1570***
		(0.0062)	(0.0062)	(0.0062)
Married		0.0534***	0.0158***	0.0153***
		(0.0039)	(0.0040)	(0.0040)
S&P500 (/100)	0.0025*	0.0034**	0.0024	0.0023
	(0.0015)	(0.0015)	(0.0015)	(0.0015)
R^2	0.024	0.095	0.125	0.128
Observations	83,468	83,468	83,468	83,468

Notes: Robust standard errors in parentheses are clustered at the individual level. Each regression model includes year fixed effects. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 3.5: The Effect of Cognitive Abilities on Risky Asset Allocation: Cognition Index

	(1)	(2)	(3)	(4)
Dependent Variable:		Stocks / FA		
	OLS	OLS	OLS	OLS
Cognition index	**0.0396******	**0.0175******	**0.0121******	**0.0098******
	(0.0013)	**(0.0014)**	**(0.0014)**	**(0.0014)**
SR health: fair				0.0058
				(0.0048)
SR health: good				0.0132**
				(0.0051)
SR health: very good				0.0383***
				(0.0056)
SR health: excellent				0.0429***
				(0.0068)
Diabetes				-0.0101**
				(0.0042)
Cancer				0.0074
				(0.0048)
Stroke				-0.0049
				(0.0062)
Heart problem				-0.0049
				(0.0040)
Health insurance			0.0107***	0.0103***
			(0.0037)	(0.0037)
Retired			0.0345***	0.0394***
			(0.0038)	(0.0038)
Log(HH income)			0.0280***	0.0271***
			(0.0016)	(0.0015)
Log(Total net worth)			0.0107***	0.0103***
			(0.0003)	(0.0003)
Age		-0.0003	-0.0036***	-0.0034**
		(0.0013)	(0.0013)	(0.0013)
Age*Age		0.00002**	0.00004***	0.00004***
		(0.00001)	(0.00001)	(0.00001)
Female		-0.0033	-0.0014	-0.0033
		(0.0040)	(0.0039)	(0.0039)
Non-Hispanic White		0.0890***	0.0636***	0.0611***
		(0.0056)	(0.0055)	(0.0056)
Non-Hispanic Black		-0.0122**	-0.0144**	-0.0141**
		(0.0060)	(0.0059)	(0.0060)
Other races		0.0297**	0.0227*	0.0222*
		(0.0129)	(0.0121)	(0.0120)
High school graduate		0.0610***	0.0453***	0.0431***
		(0.0046)	(0.0044)	(0.0044)
Some college		0.1146***	0.0906***	0.0875***
		(0.0056)	(0.0055)	(0.0055)
College graduate		0.2048***	0.1643***	0.1585***
		(0.0062)	(0.0062)	(0.0062)
Married		0.0534***	0.0157***	0.0152***
		(0.0039)	(0.0040)	(0.0040)
S&P500 (/100)	0.0027*	0.0035**	0.0024*	0.0024
	(0.0015)	(0.0015)	(0.0015)	(0.0015)
R^2	0.025	0.095	0.125	0.128
Observations	83,648	83,648	83,648	83,648

Notes: Robust standard errors in parentheses are clustered at the individual level. Each regression model includes year fixed effects. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 3.6: The Effect of Cognitive Abilities on Risky Asset Allocation: Alternative Speficiations

Dependent Variable:	(1)	(2) Stocks / FA	(3)	(4)
	$\widehat{\beta}$	dy/dx	$\widehat{\beta}$	dy/dx
Panel A: Fractional Logit				
Cognition summary score	**0.0529*****	**0.0073*****		
	(0.0088)	**(0.0012)**		
Cognition index			**0.0599*****	**0.0082*****
			(0.0109)	**(0.0015)**
Observations	83,648		83,648	
Panel B: Zero-Inflated Beta				
(Proportion model)				
Cognition summary score	**-0.0077**	**-0.0019**		
	(0.0076)	**(0.0019)**		
Cognition index			**-0.0129**	**-0.0032**
			(0.0093)	**(0.0023)**
(Zeroinflate model)				
Cognition summary score	**-0.0805*****	**-0.0135*****		
	(0.0100)	**(0.0017)**		
Cognition index			**-0.0917*****	**-0.0154*****
			(0.0122)	**(0.0021)**
Wald χ^2	178.64		179.79	
Observations	83,648		83,648	

Notes: Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, health status, household economic conditions, S&P 500 index, and year fixed effects. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 3.7: IV Regression Results: Lagged Cognitive Abilities as Instruments

Dependent Variable:	(1)	(2) Stocks / FA	(3)	(4)
	$\widehat{\beta}$	dy/dx	$\widehat{\beta}$	dy/dx
Panel A: Two-Stage Fractional Logit				
Cognition summary score	**0.0750*****	**0.0105*****		
	(0.0201)	**(0.0028)**		
Cognition index			**0.0809*****	**0.0113*****
			(0.0231)	**(0.0032)**
Observations	56,447		56,447	
Panel B: Two-Stage Zero-Inflated Beta				
(Proportion model)				
Cognition summary score	**-0.0065**	**-0.0016**		
	(0.0175)	**(0.0043)**		
Cognition index			**-0.0116**	**-0.0029**
			(0.0199)	**(0.0049)**
(Zeroinflate model)				
Cognition summary score	**-0.1163*****	**-0.0196*****		
	(0.0233)	**(0.0039)**		
Cognition index			**-0.1230*****	**-0.0207*****
			(0.0266)	**(0.0045)**
Wald χ^2	128.51		128.95	
Observations	56,447		56,447	

Notes: Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, health status, household economic conditions, S&P 500 index, and year fixed effects. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 3.8: First-Stage Regression Results: Predicting Cognitive Abilities

	(1)	(2)
Dependent Variable:	Cognition Summary Score	Cognition Index
	OLS	OLS
Eligible × Post	**0.219*****	**0.123*****
	(0.037)	**(0.031)**
CES-D score	**-0.056*****	**-0.055*****
	(0.004)	**(0.004)**
Eligibile	0.512***	0.468***
	(0.027)	(0.023)
Post	-0.298***	-0.262***
	(0.035)	(0.029)
SR health: fair	0.205***	0.190***
	(0.029)	(0.026)
SR health: good	0.372***	0.380***
	(0.031)	(0.027)
SR health: very good	0.420***	0.446***
	(0.033)	(0.029)
SR health: excellent	0.379***	0.407***
	(0.039)	(0.034)
Diabetes	-0.070***	-0.034*
	(0.022)	(0.019)
Cancer	0.082***	0.062***
	(0.024)	(0.021)
Stroke	-0.364***	-0.333***
	(0.037)	(0.033)
Heart problem	0.037*	0.036**
	(0.020)	(0.017)
Health insurance	0.094***	0.083***
	(0.018)	(0.015)
Retired	-0.063***	-0.047***
	(0.019)	(0.016)
Log(HH income)	0.068***	0.061***
	(0.007)	(0.007)
Log(Total net worth)	0.013***	0.012***
	(0.002)	(0.002)
Age	-0.057***	-0.048***
	(0.001)	(0.001)
Female	0.303***	0.252***
	(0.020)	(0.017)
Non-Hispanic White	0.405***	0.414***
	(0.036)	(0.032)
Non-Hispanic Black	-0.344***	-0.311***
	(0.043)	(0.039)
Other races	-0.124	-0.095
	(0.081)	(0.074)
High school graduate	0.612***	0.525***
	(0.021)	(0.018)
Married	-0.077***	-0.070***
	(0.020)	(0.017)
S&P500 (/100)	-0.007***	0.006**
	(0.003)	(0.002)
R^2	0.286	0.296
Observations	46,876	46,876

Notes: Robust standard errors in parentheses are clustered at the individual level. Each regression model includes year fixed effects. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 3.9: IV Regression Results: Medicare Part D and Depression Score as Instruments

	(1)	(2)	(3)	(4)
Dependent Variable:		Stocks / FA		
	$\widehat{\beta}$	dy/dx	$\widehat{\beta}$	dy/dx
Panel A: Two-Stage Least Squares - Models for risky asset allocation				
Cognition summary score	**0.0390*****			
	(0.0148)			
Cognition index			**0.0434*****	
			(0.0159)	
Observations	46,876		46,876	
Underidentification[a]	206.0		229.0	
Weak instruments[b]	165.1		198.0	
Overidentification (p-value)[c]	0.193		0.370	
Endogeneity test (p-value)[d]	0.068		0.041	
Panel B: Two-Stage Fractional Logit				
Cognition summary score	**0.3083***	**0.0333***		
	(0.1589)	**(0.0172)**		
Cognition index			**0.3307****	**0.0357***
			(0.1687)	**(0.0183)**
Observations	46,876		46,876	
Panel C: Two-Stage Zero-Inflated Beta				
(Proportion model)				
Cognition summary score	**0.0606**	**0.0150**		
	(0.1429)	**(0.0354)**		
Cognition index			**0.0451**	**0.0112**
			(0.1510)	**(0.0375)**
(Zeroinflate model)				
Cognition summary score	**-0.3630****	**-0.0534****		
	(0.1685)	**(0.0248)**		
Cognition index			**-0.3706****	**-0.0545****
			(0.1788)	**(0.0263)**
Wald χ^2	73.44		73.31	
Observations	46,876		46,876	

Notes: [a]Kleibergen-Paap rank LM-statistic (Baum, Schaffer, & Stillman, 2007; Kleibergen & Paap, 2006) tests the null hypothesis of underidenfication. [b]Kleibergen-Paap rank Wald F-statistic (Baum, Schaffer, & Stillman, 2007; Kleibergen & Paap, 2006) tests the null hypothesis of weak identification. [c]Hansen J-statistic (Baum, Schaffer, & Stillman, 2007) tests the null hypothesis of valid (exogenous) instruments which assumes a zero correlation between the instrumental variables and the error term. [d]Endogeneity test of endogenous regressors tests the null hypothesis that the specified endogenous regressors can be treated as exogenous. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, health status, household economic conditions, S&P 500 index, and year fixed effects. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 3.10: Regression Results with Lagged Cognition Variables

	(1)	(2)	(3)	(4)
Panel A: OLS for Risky Asset Allocation				
Cognition index	0.0098***			
	(0.0014)			
Cognition index$_{t-1}$		0.0085***		
		(0.0018)		
Cognition index$_{t-2}$			0.0095***	
			(0.0023)	
Cognition index$_{t-3}$				0.0082***
				(0.0027)
R^2	0.128	0.133	0.128	0.125
Observations	83,648	56,447	41,181	28,893
Panel B: Logit for Risky Asset Ownership (marginal effects)				
Cognition index	0.0153***			
	(0.0021)			
Cognition index$_{t-1}$		0.0125***		
		(0.0028)		
Cognition index$_{t-2}$			0.0123***	
			(0.0034)	
Cognition index$_{t-3}$				0.0125***
				(0.0040)
Pseudo R^2	0.213	0.222	0.211	0.204
Observations	83,648	56,447	41,181	28,893

Notes: Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, health status, household economic conditions, S&P 500 index, and year fixed effects. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 3.11: The Effect of Cognitive Abilities on Risky Asset Ownership by Marital Status and Household Size

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:		Hold Stocks			Hold Stocks or Bonds	
		Female	Male		Female	Male
	Logit	Logit	Logit	Logit	Logit	Logit
Panel A: By marital status						
Cognition index	0.1212***	0.1150***	0.1231***	0.1182***	0.1138***	0.1181***
	(0.0191)	(0.0227)	(0.0375)	(0.0187)	(0.0223)	(0.0362)
Married	0.2990*	0.4160*	0.1245	0.3001*	0.4613**	0.0657
	(0.1663)	(0.2144)	(0.2942)	(0.1622)	(0.2097)	(0.2834)
Cognition index × Married	-0.0474**	-0.0663**	-0.0207	-0.0502**	-0.0736***	-0.0193
	(0.0218)	(0.0276)	(0.0397)	(0.0213)	(0.0271)	(0.0383)
Pseudo R^2	0.213	0.226	0.195	0.220	0.232	0.202
Observations	83,648	48,222	35,426	83,648	48,222	35,426
Panel B: By household size						
Cognition index	0.1245***	0.1216***	0.1234***	0.1200***	0.1196***	0.1137***
	(0.0215)	(0.0255)	(0.0415)	(0.0209)	(0.0250)	(0.0399)
Household size > 1	0.2431	0.3776*	0.0438	0.2244	0.3969*	-0.0492
	(0.1763)	(0.2177)	(0.3210)	(0.1714)	(0.2125)	(0.3078)
Cognition index × Household size > 1	-0.0485**	-0.0674**	-0.0212	-0.0491**	-0.0724***	-0.0143
	(0.0233)	(0.0285)	(0.0433)	(0.0227)	(0.0279)	(0.0416)
Pseudo R^2	0.213	0.226	0.195	0.220	0.232	0.203
Observations	83,648	48,222	35,426	83,648	48,222	35,426

Notes: This table presents parameter estimates from the Logit regression results. Column (2) and (5) fit the models for females and column (3) and (6) fit the models for males. Robust standard errors in parentheses are clustered at the individual level. Each regression model includes demographic covariates, health status, household economic conditions, S&P 500 index, and year fixed effects. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 3.12: Cognitive Abilities and Risky Asset Ownership: Finding Mechanisms

	(1)	(2)	(3)	(4)	(5)
Dependent Variable:			Hold Stocks		
	Logit	Logit	Logit	Logit	Logit
Cognition index	0.0799***	0.1195***	0.1199***	0.0841	0.1290***
	(0.0198)	(0.0409)	(0.0372)	(0.0859)	(0.0380)
Planning horizon: next year	0.1973***	0.5898			0.1924
	(0.0613)	(0.4280)			(0.1264)
Planning horizon: next few years	0.2891***	0.7597**			0.1518
	(0.0541)	(0.3714)			(0.1015)
Planning horizon: next 5-10 years	0.3331***	0.7198*			0.3198***
	(0.0547)	(0.3782)			(0.0965)
Planning horizon: > 10 years	0.3806***	0.1876			0.3199***
	(0.0689)	(0.4783)			(0.1117)
Risk aversion: 3rd. most risk averse			-0.0541	-0.2390	-0.0547
			(0.1126)	(1.0358)	(0.1141)
Risk aversion: 2nd. most risk averse			-0.0391	-0.7252	-0.0300
			(0.0998)	(0.9508)	(0.1009)
Risk aversion: most risk averse			-0.1391*	-0.4124	-0.1257
			(0.0823)	(0.7602)	(0.0836)
Cognition index × PH: next year		-0.0523			
		(0.0561)			
Cognition index × PH: next few years		-0.0624			
		(0.0487)			
Cognition index × PH: next 5-10 years		-0.0513			
		(0.0493)			
Cognition index × PH: > 10 years		0.0230			
		(0.0619)			
Cognition index × RA: 3rd. most risk averse				0.0227	
				(0.1288)	
Cognition index × RA: 2nd. most risk averse				0.0849	
				(0.1175)	
Cognition index × RA: most risk averse				0.0339	
				(0.0943)	
Pseudo R^2	0.208	0.208	0.159	0.159	0.160
Observations	22,878	22,878	6,881	6,881	6,701

Notes: This table presents parameter estimates from the Logit regression results. Each regression model includes demographic covariates, health status, household economic conditions, S&P 500 index, and year fixed effects. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 3.13: Cognitive Abilities and Risky Asset Ownership: Alternative Cognition Measures

	(1)	(2)	(3)	(4)
Dependent Variable:		Hold Stocks		
	Logit	Logit	Logit	Logit
Episodic memory	0.0172***		0.0176***	
	(0.0035)		(0.0035)	
Mental status	0.0340***		0.0343***	
	(0.0061)		(0.0061)	
Immediate word recall		0.0289***		0.0295***
		(0.0087)		(0.0087)
Delayed word recall		0.0088		0.0091
		(0.0071)		(0.0071)
Serial 7's		0.0471***		0.0474***
		(0.0082)		(0.0082)
Backward counting		0.0092		0.0092
		(0.0235)		(0.0235)
Date naming		-0.0351**		-0.0345**
		(0.0171)		(0.0171)
Object naming		0.0518		0.0513
		(0.0464)		(0.0465)
President/vice-president naming		0.0615***		0.0625***
		(0.0236)		(0.0235)
SR memory: fair			0.0154	0.0149
			(0.0442)	(0.0442)
SR memory: good			0.0681	0.0685
			(0.0454)	(0.0453)
SR memory: very good			0.0377	0.0384
			(0.0498)	(0.0498)
SR memory: excellent			0.0865	0.0806
			(0.0699)	(0.0699)
Pseudo R^2	0.213	0.214	0.213	0.214
Observations	83,648	83,648	83,648	83,648

Notes: This table presents parameter estimates from the Logit regression results. Each regression model includes demographic covariates, health status, household economic conditions, S&P 500 index, and year fixed effects. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

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Chapter 4

Essay III: Subjective life expectancy and portfolio choice: A household bargaining approach

4.1 Introduction

Married men and women might develop different preferences towards household savings and consumption as they reach the retirement age. It is widely acknowledged that women, on average, live longer than men, and most wives are younger than husbands. In the U.S., a typical 65-year-old woman could expect to live another 20.5 years (to age 85.5), while this span reduces to 17.9 years (to age 82.9) for a man (Xu, Kochanek, Murphy, & Arias, 2012). Historically, the mean age disparity at marriage remained around 2 to 3 years in the U.S. (Wang, 2012). These two facts, overall, indicate 5 or 6 years longer retirement period for women to finance.

Under plausible assumptions on intertemporal decision-making, women approaching retirement age have more incentive to save since they should prepare for a longer retirement period. According to the life-cycle hypothesis (Ando & Modigliani, 1963), forward-looking wives with longer life expectancy should prefer to cut spending and increase household saving rates across the periods. While this is generally the case, some women may not want to increase saving but rather want to consume more for the benefit of their children (Lundberg & Ward-Batts, 2000). In either case, conflict of interest arises between husband and wife because spouses differ in their preferences. Bargaining models then suggest that saving for old-age provision is the outcome of bargaining process, and in large part determined by who has more bargaining power and who is more likely to impose his/her preferences (Browning, 2000; Gibson, Le, & Scobie, 2006).

Despite the importance of bargaining process in savings decision, most literature postulated a household acting as a single decision-making unit characterized by one utility function.[1] This unitary approach, in theory, is relevant as long as household's preference coincide with individual preferences, given pooled and jointly managed family resources. However, subsequent studies demonstrated that this assumption rarely holds in practice due to large gender-related differences in preference (Vermeulen, 2002). For instance, women and men tend to respond to financial risks differently, with women generally displaying more risk aversion (Croson & Gneezy, 2009; Jianakoplos & Bernasek, 1998). Men tend to be more overconfident than women, and thus trade excessively and fail to diversify their investment portfolios (Barber & Odean, 2001). Men discount future rewards more rapidly (Coller & Williams, 1999; Silverman, 2003), and are less likely to be future-oriented (Zimbardo, Keough, & Boyd, 1997). Clearly, there is a sizable evidence that married couple does not behave as a single decision-making unit, and unitary framework cannot be used to analyze the economic behaviors of households.

Although a growing body of literature examined household savings decision within bargaining context, the results have been largely mixed and somewhat inconclusive. Lee and Pocock (2007), for instance, found greater saving when a wife has control over the resources within the household. Lundberg and Ward-Batts (2000) found limited evidence in which household net worth varies with a low relative education of wives, but not with other factors that might determine their bargaining powers. Browning (1995) found rather a low household saving rate among households when the wife earns more. Subsequent studies in Canada (Phipps & Woolley, 2008), Germany (Keese, 2011), and New Zealand (Gibson et al., 2006) are also in line with Browning in that household's net worth decreases with women's bargaining power, who may prefer to save. Even among the literature that employed unitary

[1] See, for example, Berkowitz and Qiu (2006), Christelis, Jappelli, and Padula (2010), De Nardi, French, and Jones (2009), Dimmock and Kouwenberg (2010), Heaton and Lucas (2001), and Rosen and Wu (2004).

approach, numerous studies documented lower saving rate among women, which pose more fundamental questions about gender effects on savings (Brown, 2012; Fisher, 2010).

In this essay, I propose at least three issues that have been neglected in the literature and argue that a systematic consideration of such issues leads to the outcome that is consistent with bargaining models. First, it is unrealistic to expect the elderly significantly increase saving at retirement stage for any reason. For instance, those who already retired may have limited income source which deters them from saving for old age. The younger elderly at pre-retirement stage may have accumulated the most savings of life, and thus have a lower marginal propensity to save. If then, it would be more plausible to assume that households rebalance their portfolio towards risky assets that yield higher expected capital gains in the long-term, rather than adjusting saving and consumption (Mazzocco, 2004).[2]

Second, the previous studies proceed with the assumption that both spouses know their own demise with certainty. While such assumption has generally been accepted, a more precise description would be that individuals form their own expectations regarding remaining life years, such as how likely they are to survive to a certain age.[3] Individuals, in general, would make a prediction about their life expectancy by accessing and processing a considerable amount of private information on relevant issues such as current health conditions and family history of the disease (Hurd, 2009; Perozek, 2008). In essence, such judgments are subjective in nature, but the literature failed to take that into account. More importantly, some people may have limited ability to make probabilistic judgment according to Bayes' rule so as to expect unrealistically long or short lifespan (Hurd & McGarry, 2002). That is, individuals' perceived life expectancy, which might be the basis of savings and investment

[2]One might argue that, if the differences in life expectancy between spouses determine portfolio riskiness, it might also affect the absolute amount of saving. Note that risk sharing, although it is conceptually different from portfolio risk, crowds out saving if and only if spouses' discount factors and beliefs are identical (Mazzocco, 2004). As Browning (2000) argued, however, husband's and wife's discount factors are likely to be different, with wife facing longer living horizon. This indicates that portfolio reallocation at the end of life is largely independent of savings decision.

[3]See, for example, Romm (2015) for the relationship between retirement date expectations and pre-retirement wealth.

decision (Spaenjers & Spira, 2015), would be markedly different across individuals and hardly correlate with gender and age.[4]

This study adds to the growing body of intra-household bargaining literature by revisiting the issue of portfolio choice and the husband-wife difference in life expectancy. In theory, wives who expect a longer lifespan ought to be better off with risky portfolio because stocks are less risky over longer investment horizons and almost always more profitable than riskless assets (Barberis, 2000; Bec & Gollier, 2009). Faced with a relatively short lifespan, husbands may prefer to purchase goods and services that enhance utility immediately or invest in health in order to prolong their lifespan, even though a marginal increase in longevity is trivial. In either case, husbands with a shorter horizon have an incentive to liquidate resources held in illiquid financial assets or other forms of fixed assets to meet their present consumption needs.

In this study, the incentive to bargain over the riskiness of portfolio is modeled by a collective bargaining framework in which the household maximizes the weighted sum of husbands and wife's utility (Chiappori, 1988; 1992; Lundberg & Ward-Batts, 2000). Unlike Browning (2000) which builds upon non-cooperative framework, I assume that old married couple's decision making who pool the resources is joint and cooperative. This assumption is particularly appropriate because joint and harmonious decisions are more prevalent among older couples (Zepeda, Castillo, McSweeney, & Undersander, 1996). Following Browning's formulation, however, the difference in the subjective life expectancy between spouses is modeled as an additional discount factor that reduces husband's utility more rapidly. Since the spouse with bargaining power is more likely to impose his/her preferences, the riskiness of family portfolio is to increase with the expected longevity of decision maker. Intuitively, the share of risky assets in a household portfolio will be higher (or, lower) if a spouse expecting

[4]Although the essence of bargaining models is heterogeneous preferences between decision-makers, most previous studies focused heavily on gender as an indicator of such difference in preferences. Since the motive of bargaining, such that wives are younger and live longer than husbands, is not necessarily gender-specific, previous findings could be plagued by noise in the indicator of preference.

longer (or, shorter) living horizon has more control. My theoretical model illustrates that the risk profile of portfolio would be determined by the relative difference in life expectancy and distribution of bargaining power within a household.

Empirically, this study models the extent to which the perceived lifespan of financial respondent (i.e., a spouse with more bargaining power) and non-financial respondent (i.e., a spouse with less bargaining power) associate with the riskiness of portfolio, conditioned on their individual- and family-specific characteristics. Following the literature, the subjective survival probability (SSP) in the Health and Retirement Study is used to proxy for individuals' perceived living horizon (Hurd, 2009). The riskiness of portfolio is captured by stock ownership and the proportion of financial wealth held in equities, assuming a joint decision of whether to hold and how much to allocate to risky assets. My hypothesis about joint portfolio choice is tested by examining whether the riskiness of portfolio increases more significantly with the SSP of spouse with greater bargaining power.

The estimation results are in line with the predictions from the collective bargaining model. The riskiness of portfolio significantly grows with the subjective lifespan of decision-making spouse, while the impact of non-decision maker's subjective lifespan is at best trivial. For instance, a 10 percentage points increase in the financial respondent's SSP beyond age 75 is associated with 0.32 percentage points greater share of stocks and 0.37 percentage points greater stock ownership, while the non-financial respondent's SSP has no discernible impact on portfolio allocation. The riskiness of portfolio is, overall, less responsive to the changes in SSP beyond age 80-100, although the financial respondent's SSP still has a dominant impact. An interesting interaction between gender and bargaining power is also found. When husbands have more bargaining power, I find that risky asset share increases with the SSP of both spouses, and when wives have the "final say" only wives' SSP affects portfolio allocation. These findings show a strong evidence of collective decision-making, which is in line with the life-cycle hypothesis.

4.2 Literature Review

4.2.1 Household Bargaining and Savings for Old Age

The savings decision of a married couple is different from the choice of a single person, and especially for a family that pools economic resources such decisions are often made jointly within a household. Given the age disparity at marriage and longer lifespan of women, husbands and wives are likely to develop different preferences toward savings for old age, with wives expecting more extended retirement period to finance. This suggests that wives at retirement stage would prefer to hold greater net worth and cut spending while husbands relatively less prefer to delay consumption.

One of the first studies that modeled such disparity using a bargaining framework is Browning (1995). In his study, Browning argued that a joint decision of saving and consumption depends heavily on the source of income - that is, who brings how much income to the household, not the absolute amount of household saving. Contrary to his theoretical framework, the estimates showed somewhat counterintuitive relationship such that household saving rate decreases with the proportion of household income contributed by a wife. Motivated by this conflicting finding, Lundberg and Ward-Batts (2000) revisited the issue with alternative measures of bargaining power. Lundberg and Ward-Batts first noticed that Browning's estimates are plagued by the endogeneity of income - a high correlation between the distribution of income and total household income, and the selection of sample well ahead of retirement age. To circumvent such endogeneity, they proposed non-income based measures, such as the difference in age and education background, or more exogenous measures using state marital property laws and divorce laws. In their analysis of American sample, household net worth was 35% lower among the families in which husband has eight or more education beyond wife. While such finding is clearly in line with the predictions from bargaining models, their results are not robust to other bargaining measures.

Varadharajan (2003) argued that the measures of bargaining power, such as those proposed by Lundberg and Ward-Batts (2000) and other related studies,[5] are at best noisy and hardly correlate with one another. It is, therefore, uncommon to find inconsistency across the literature, due solely to the error in the measurement of bargaining power. Gibson et al. (2006) took an alternative path of estimating a single index that represents spouse' relative control over the financial resources. To construct such index, the authors conducted factor analysis on the difference in age, years of education, and expectations of inheritance, in order to extract the shared variance between these measures. The proportion of wife's income, which was employed in the earlier studies, is replaced by this factor score in the regression models for household net worth. Surprisingly, they also found the negative association between women's bargaining power and household saving rate, irrespective of how total income is controlled. While the authors attributed this contradictory finding to the distinctive structure of New Zealand's pension system (i.e., higher replacement rates for women's pre-retirement income), their interpretations could not fully explain the puzzling findings from other studies.

In a study of German sample, Phipps and Woolley (2008) examined the extent to which spouses' control over household finances associates with a contribution to tax-sheltered registered retirement savings plans (RRSP). The contribution rate to RRSP was significantly low among the families in which wife has the "final say", regardless of whether the plan is owned by husband or wife. This pattern is, again, in sharp contradiction to what bargaining models would predict. According to the authors, this could be due to the traditional gender role that makes husbands care for their wives' old-age provision, or women's different spending pattern which favors the well-being of their children. A subsequent study of Keese (2011) also found a similar negative impact of wives' bargaining power on the propensity to save. In the subsample analysis, they found strong consumption needs among the households in which parents live with children while a wife has "final say". This pattern was not preserved

[5] See, for example, Babiarz, Robb, and Woodyard (2012), Friedberg and Webb (2006), Jianakoplos and Bernasek (2008), Neelakantan, Lyons, and Nelson (2009), and Yilmazer and Lyons (2010).

with another subsample, limited to those without children living in the same household. This pattern is in support of the second explanation of Phipps and Woolley, which is then named as "good mom" hypothesis.

Instead of examining the imprecise measure of bargaining power, Romm (2015) explicitly accounted for individuals' expected retirement date to test bargaining-saving correlation. This study begins with the assumption that consumption smoothing requires individuals to form appropriate predictions regarding life-cycle parameters, such as when to retire and how likely to survive, and such information more directly captures the incentive to bargain over saving/consumption (Lundberg, Startz, & Stillman, 2003). By linking pre-retirement net worth to husband's and wife's expected retirement date, they found that pre-retirement wealth is much less accumulated when a husband is a financial decision maker and more likely to work past age 62.

4.2.2 Household Bargaining and Allocation of Savings

Households' financial decision-making can be roughly categorized into two domains: they may first decide how much income to spend out and how much to save for future consumption, and then allocate this saving between risky and risk-free assets (Neelakantan et al., 2009). With somewhat mixed and inconclusive evidence of savings-bargaining correlation, another body of studies delved into whether and to what extent the possible conflicts of interests between spouses affect the risk structure of portfolio. Men typically have greater financial risk tolerance than women (Schubert, Brown, Gysler, & Brachinger, 1999), seek risks even in everyday life (Hersch, 1996), tend to be overconfident (Barber & Odean, 2001), and discount future rewards more rapidly (Coller & Williams, 1999; Silverman, 2003). In a similar vein as savings decision, assuming a single decision-making unit with a common utility function and pooled income is unlikely to explain married couples' portfolio choice.

To the best of my knowledge, the first study that employed lifespan to capture such differences in preference is Browning (2000).[6] Browning argued that a wife, who is expected to survive longer and generally younger in marriage, has a greater incentive to save to maintain a living standard after widowhood. On the basis of non-cooperative bargaining framework, Browning formulated a two-period model where the household savings and portfolio choice are related to the distribution of income between spouses. Browning's framework gives two sharp predictions. First, the allocation of savings, for instance, between annuities, life insurance, and private saving, is in part determined by the distribution of income within the household, and the effect of extra income depends on who brings such money to the family. For instance, husbands, who can expect a higher rate of return from annuities, would never choose to save, and likewise, wives faced with longer horizon would never contribute to annuities. The bargaining process then leads to the particular portfolio composition where no husband/wife can be made better off without making another spouse worse off. Second, the non-cooperative process always leads to this Pareto efficient outcome, as in collective or cooperative bargaining models. Wong (2015) provided empirical support for this framework. In a study of life insurance ownership, the author found that the desired amount of life insurance coverage for husband decrease with a shift of bargaining power to husband.

A subsequent work by Friedberg and Webb (2006) provided more direct evidence of marital bargaining over portfolio riskiness. By exploring a direct measure of "final say", the authors tested whether household wealth and portfolio allocation vary with the relative bargaining power, in a manner consistent with the predictions from bargaining models. In their study, the riskiness of portfolio increased when the husband has greater control over family resources, with the associations more pronounced for stock ownership than portfolio allocation. Motivated by greater risk aversion among women, Yilmazer and Lyons (2010) examined the extent to which spouse's relative bargaining power associates with the riskiness of pension plan. By analyzing married couples of pre-retirement age, they found that financial

[6] See Neelakantan et al. (2009) for a similar two-period model built on the collective framework.

assets are less allocated to defined contribution (DC) plans among the households whose wife has more bargaining power.

While the literature demonstrated a gender-related difference in risk aversion, more direct evidence of bargaining would be uncovered by assessing the interaction between individuals' preference and bargaining power, rather than just examining gender effect. In Yilmazer and Lich (2015), such issue is explicitly taken into account by interacting risk aversion, measured by hypothetical income gambling questions (Barsky, Juster, Kimball, & Shapiro, 1997), with two exogenous measures of bargaining. Empirically, they tested to what extent relative bargaining power moderates the impact of risk aversion on portfolio composition. Their findings showed that more financial wealth is allocated to risky assets as the risk aversion of financial decision maker decreases.

Jianakoplos and Bernasek (2008) used relative earning share to proxy for bargaining power and estimated portfolio choice models in a similar context. This study, overall, found only limited evidence of greater financial risk-taking when a wife has more financial control, which is in contrast to underlying theory. Their findings were qualitatively similar to Browning (1995) where the estimation results are clouded by the endogeneity of income-based bargaining measure. Note that this type of contradictory findings was also reported in Yilmazer and Lich (2015) when income share is used for robustness checks. As reviewed so far, there is more than enough evidence that bargaining power cannot be represented by income share, unless endogeneity (of income) is explicitly taken into account.

4.2.3 Life Cycle Stage and Portfolio Choice

Before the discussion of unitary/collective decision-making, much more attention is paid the evolution of household portfolio over the life cycle. Early theoretical models of asset allocation, such as dynamic models of Mossin (1968), Samuelson (1969) and Merton (1969), showed that household portfolio hardly varies over the life. Built on the assumption of complete market, *i.i.d.* returns, and additively separable utility, these dynamic models yielded two important predictions. First, at all periods of the life-cycle individuals contribute at least some amount of their wealth to risky assets. That is, it is rational for individuals to participate in the equity market regardless of their age. Second, if an individuals utility exhibits constant relative risk aversion (CRRA) and asset prices are normally distributed, myopic investment strategies are rational. The investment strategies are myopic in the sense that the decisions are made independent of returns beyond the current period. Myopic investors arrive at the optimal risk exposure by analyzing only current periods wealth and investment opportunities, without taking into account any condition beyond the current period. Thus, the asset allocation should remain nearly invariant under a change of investment horizon, lifespan, and age.

Unlike the predictions from dynamic models, empirical studies commonly reported a strong age-related pattern of portfolio composition (Ameriks & Zeldes, 2004; King & Leape, 1987). Stock market participation versus age is typically hump-shaped: lower early in life and also lower later in life as people retire and leave the equity market (see Guiso, Haliassos, & Jappelli, 2002). The participation rate peaks around 60's, with about 60% of households holding stocks either directly or indirectly (Fagereng, Gottlieb, & Guiso, 2015). Although this hump-shaped profile is not in line with dynamic models, it conforms to the well-known financial advice that recommends less exposure to financial risks at the end of life (Malkiel, 1996). Indeed, this type of financial advice is not non-sensical because investors who face longer investment horizons have more time to bounce back from transient losses (Gollier & Zeckhauser, 2002), and investments in equities are less risky over a longer horizon (Barberis, 2000; Bec & Gollier, 2009).

In an attempt to find the evidence of hump-shaped stockholding pattern, empirical studies focused on separating the age effect from time and cohort effects that could confound the effect of age (Ameriks & Zeldes, 2002; Poterba & Samwick, 1997). Intuitively, the association between age (or, investment horizon) and portfolio structure could be due to the unobserved factors that correlate with stock market participation while varying over time. For example, cohorts of investors who grew up in different times could have developed different tastes for risky assets (cohort effects), or preferences towards asset allocations could itself be influenced by the economic climates (time effects). As Ameriks and Zeldes pointed out, these three factors (i.e., age, cohort, and time effects) essentially move together, and thus the effect of age cannot be fully disentangled. Ameriks and Zeldes' solution was then to estimate two sets of models: (a) the first set that excludes time components but only includes age and cohort effects; and (b) the second set that excludes only cohort effects while retaining other two effects. Even after accounting for the confounders, risky asset ownership remained hump-shaped over age whereas the conditional share of wealth held in stocks no longer depends on age.

Although the elderly are more likely to face shorter investment horizons, their age may or may not determine portfolio composition in a manner consistent with their investment horizon. Intuitively, investment horizon captures *ex-ante* consumers' time frame for investment, while age represents a flow of calendar time. That is, a passage of one calendar year does not necessarily correspond to one-year shorter investment horizon. In this respect, individuals' life-cycle decisions might be explained much better by subjective horizon than age (Romm, 2015). Many previous studies, however, failed to account for subjective investment horizon, such as when to retire and how likely to survive to a certain age, all of which constitute important private information that determines perceived investment horizon (Hurd, 2009). For instance, if individuals over-react to the onset of health conditions, the investment horizon would be reduced more than one calendar year. On the other hand, such health information could not be updated if individuals have no good access to medical checkups or behavoral bias deters them from forming a precise expectation.

Arguably, there is enough evidence that subjective life horizon is associated with consumption-savings decisions (Biro, 2013; Hurd, McFadden, & Gan, 1998; Salm, 2010). For instance, Gan, Gong, Hurd, and McFadden (2004) assessed the explanatory power of subjective lifespan by comparing subjective survival probabilities (SSP) to life table mortality risks. They showed that a model based on SSP had a better fit than a model based on life table values, conditioned upon age and health conditions. That is, one's savings decisions are affected more strongly by his beliefs about remaining life years than by population average mortality risks. Spaenjers and Spira (2015) directly linked the subjective life horizon to the riskiness of portfolio and found that individual investors indeed rely on the perceived investment horizon when making a portfolio choice.

4.3 Theoretical Framework

The conceptual framework of this study postulates a two-person family composed of agent a and b who live for period 1 and 2.[7] Individuals are assumed to draw utilities only from consumption in each period, subject to family budget constraints. The preferences of agent a and b are characterized by the their own utility functions $u^a(c_t)$ and $u^b(c_t)$, where c_t represents the joint consumption of public goods in each period. The utility functions are twice continuously differentiable and monotonically increasing in the consumption of public goods (i.e., well-behaved). For simplicity, private consumptions are ruled out.

In period 1, a family is endowed with pooled resources w_1 which is the sum of individual's exogenous net worth. A part of this initial endowment can be spent on public goods or saved in the form of risky or risk-free assets. Assuming s_1 is household savings in period 1 and δ denotes the proportion of savings held in risky assets, δs_1 and $(1-\delta)s_1$ represent household savings in the form of risky and risk-free assets, respectively. The return on risk-free assets is assumed constant, whereas the return on risky asset follows a probabilistic distribution (e.g., normal distribution). Thus, $1 + r$ denotes the return on risky assets with the cumulative distribution function $F(1 + r)$. The fixed return on risk-free assets is treated as numeraire and thus 1 in the model. The family consumes c_1 and save $\delta s_1 + (1 - \delta)s_1$ in period 1,

[7] The theoretical framework is motivated by Browning (2000) where a difference in life expectancy between spouses is modeled as a discount rate shifter. As discussed, this framework builds upon collective bargaining framework of Chiappori (1988; 1992) and Mazzocco (2004) and closely follows the modeling strategies of Neelakantan et al. (2009) and Yilmazer and Lich (2015).

which is less than or equal to the initial endowment w_1. The consumption in period 2 is then restricted by the savings with realized return, which is $\delta s_1 \cdot (1+r) + (1-\delta)s_1$.

Assuming γ denotes the discount rate, agent a and b derive the following utilies from the first period:

$$\begin{aligned} &u^a(c_1) + \left(\frac{1}{1+\gamma^a}\right) u^a(c_2) \\ &u^b(c_1) + \left(\frac{1}{1+\gamma^b}\right) u^b(c_2) \end{aligned} \tag{4.1}$$

Note that $c_1 \leq w_1 - s_1$ and $c_2 \leq s_1(\delta \cdot r + 1)$, indicating that c_2 is a function of stochastic outcomes. Postulating a von Neumann-Morgenstern utility function, the following expected utilities are defined.

$$\begin{aligned} E[u^a(c_2)] &= \int u^a\big(s_1(\delta \cdot r + 1)\big) \cdot dF(r) \\ E[u^b(c_2)] &= \int u^b\big(s_1(\delta \cdot r + 1)\big) \cdot dF(r) \end{aligned} \tag{4.2}$$

Given that individuals with longer horizon discount future utilities less rapidly (Hong & Hanna, 2014), the difference in the subjective life expectancy between two agents is modeled as a scale parameter of a discount rate. Both agents are assumed to survive period 1 with no uncertainty, but face different probabilities of survival in period 2 and beyond. No divorce is permitted throughout the study period. From now on, I assume that agent a is the spouse with longer subjective life expectancy; SSP denotes subjective survival probability; and λ represents the proportion of SSP between two agents. That is,

$$\lambda = \frac{SSP^a}{SSP^b} \geq 1 \tag{4.3}$$

and, individual expected utilities become:

$$\begin{aligned} &u^a(c_1) + \left(\frac{1}{1+(\gamma/\lambda)}\right) E[u^a(c_2)] \\ &u^b(c_1) + \left(\frac{1}{1+\gamma}\right) E[u^b(c_2)] \end{aligned} \tag{4.4}$$

where $E[u^a(c_2)]$ and $E[u^b(c_2)]$ are as in equation (4.2), and γ captures the discount rate of the spouse with lower SSP.

The collective bargaining framework imposes a Pareto-optimal joint solution in which the couple maximizes a weighted sum of their individual utilities (Browning, Bourguignon, Chiappori, & Lechene, 1994; Browning & Chiappori, 1998; Chiappori, 1988; 1992). The optimal consumption and portfolio choice are determined by solving:

$$\max_{c_1,c_2,s_1,\delta} \;\; \mu(\phi)\left[u^a(c_1) + \left(\frac{1}{1+(\gamma/\lambda)}\right)E[u^a(c_2)]\right] + (1-\mu(\phi))\left[u^b(c_1) + \left(\frac{1}{1+\gamma}\right)E[u^b(c_2)]\right]$$

subject to:

$$\begin{aligned} c_1 + \delta s_1 + (1-\delta)s_1 &\leq w_1 \\ c_2 &\leq \delta s_1 \cdot (1+r) + (1-\delta)s_1 \end{aligned}$$

The Pareto weight $\mu(\phi)$ and $1-\mu(\phi)$ capture the relative bargaining power of the agents where ϕ is a set of exogenous factors that influence bargaining power.

In this study, a particular functional form of individual utility is not postulated. Instead, I assume that a Pareto optimal outcome $\delta^* = \arg\max \mu(\phi)\left[u^a(c_1) + \left(\frac{1}{1+(\gamma/\lambda)}\right)E[u^a(c_2)]\right] + (1-\mu(\phi))\left[u^b(c_1) + \left(\frac{1}{1+\gamma}\right)E[u^b(c_2)]\right]$ always exists, and the first- and second-order condition for constrained maximization are satisfied as in Yilmazer and Lich (2015). That is, $\partial V(\delta^*, \mu(\phi)) \;/\; \partial\delta = 0$ and $\partial^2 V(\delta^*, \mu(\phi)) \;/\; \partial\delta^2 < 0$. Assuming $c_1 = w_1 - s_1$ and $c_2 = s_1(\delta \cdot r + 1)$, the first-order condition at equilibrium is:

$$\begin{aligned} V^*(\delta^*) = {} & \mu(\phi)\left[u^a(w_1 - s_1) + \left(\frac{1}{1+(\gamma/\lambda)}\right)\int u^{a'}\big(s_1(\delta^* \cdot r + 1)\big)r \cdot dF(r)\right] \\ & + (1-\mu(\phi))\left[u^b(w_1 - s_1) + \left(\frac{1}{1+\gamma}\right)\int u^{b'}\big(s_1(\delta^* \cdot r + 1)\big)r \cdot dF(r)\right] \\ = {} & 0 \end{aligned} \tag{4.5}$$

Since the bargaining weight $\mu(\phi)$ is bounded between zero and unity, either the first or second term should be positive and the other term should be negative. Under the plausible assumption that the rate of return on risky assets is greater than one, the first term in equation (4.5) can be positive if and only if expected utility increases with the riskiness of savings. Similarly, the second term in equation (4.5) can be negative if and only if expected utility decreases with the riskiness of savings. In this derivation, agent a is assumed to face longer life horizon, so as to derive more utility from a risky portfolio. Agent b, whose expected lifespan is shorter, draws negative expected marginal utility, and thus prefers a portfolio with low financial risks. In turn, δ^* indicates a steady-state equilibrium (or, Pareto efficient solution) where neither agents can be better off without making another agent worse off. Taking these conditions together, I find

$$\begin{aligned} u^a(w_1 - s_1) + \left(\frac{1}{1+(\gamma/\lambda)}\right) \int u^{a'}\big(s_1(\delta^* \cdot r + 1)\big) r \cdot dF(r) > 0 \\ u^b(w_1 - s_1) + \left(\frac{1}{1+\gamma}\right) \int u^{b'}\big(s_1(\delta^* \cdot r + 1)\big) r \cdot dF(r) < 0 \end{aligned} \tag{4.6}$$

With this formulation, the first-order condition leads to two testable predictions. First, the bargaining process leads to a riskiness of portfolio in favor of the spouse with greater bargaining power. If I assume that a sharing rule $\mu(\phi)$ is no longer exogenous, the partial derivative of δ^* with respect to $\mu(\phi)$ can be derived by the implicit function theorem. This condition is given by:

$$\frac{\partial \delta^*}{\partial \mu} = -\frac{\frac{\partial}{\partial \mu}\left(\frac{\partial V(\delta^*, \mu(\phi))}{\partial \delta}\right)}{\frac{\partial}{\partial \delta}\left(\frac{\partial V(\delta^*, \mu(\phi))}{\partial \delta}\right)}$$

Note that a denominator is nothing but a second-order condition, which is assumed to be negative by assumption. Solving the numerator leads to the following expression:

$$\begin{aligned} \frac{\partial}{\partial \mu}\left(\frac{\partial V^*}{\partial \delta}\right) = & \left[u^a(w_1 - s_1) + \left(\frac{1}{1+(\gamma/\lambda)}\right) \int u^{a'}\big(s_1(\delta^* \cdot r + 1)\big) r \cdot dF(r)\right] \\ & - \left[u^b(w_1 - s_1) + \left(\frac{1}{1+\gamma}\right) \int u^{b'}\big(s_1(\delta^* \cdot r + 1)\big) r \cdot dF(r)\right] \\ & > 0 \end{aligned}$$

Note that this amount is always positive, assuming that the expected marginal utility of agent b is negative. $\partial\delta^*/\partial\mu$ is then always greater than zero, indicating that the increase (decrease) in the bargaining power of agent a would increase (decrease) the proportion of savings held in risky assets. Second, the riskiness of portfolio further increase as the relative difference between the SSP of financial spouse and the other spouse gets larger. Assuming an infinitesimal change in $\lambda = SSP^a/SSP^b$, the implicit function theorem also leads to:

$$\frac{\partial \delta^*}{\partial \lambda} = -\frac{\frac{\partial}{\partial \lambda}\left(\frac{\partial V(\delta^*, \mu(\phi))}{\partial \delta}\right)}{\frac{\partial}{\partial \delta}\left(\frac{\partial V(\delta^*, \mu(\phi))}{\partial \delta}\right)}$$

Again, the denominator is negative and the first-order condition is differentiable. If the bargaining power is independent of λ, $\frac{\partial}{\partial \lambda}\left(\frac{\partial V(\delta^*, \mu(\phi))}{\partial \delta}\right)$ is as follows:

$$\frac{\partial}{\partial \lambda}\left(\frac{\partial V^*}{\partial \delta}\right) = \mu(\phi)\left[u^a(w_1 - s_1) + \frac{\gamma}{\lambda^2}\left(\frac{\lambda}{\lambda+\gamma}\right)^2 \int u^{a'}\big(s_1(\delta^* \cdot r + 1)\big) r \cdot dF(r)\right] > 0$$

Therefore, $\partial \delta^*/\partial \lambda$ is always positive. This condition shows that as the difference between the SSP of financial respondent and non-financial respondent increases more savings are allocated to risky assets. Before interpreting this prediction, note that an agent who faces longer expected lifespan is supposed to have a preference leaning towards risky assets, and λ is not formulated as a component that determines one's preference. That is, a difference in SSP between spouses is nothing but a slope shifter that amplifies the impact of decision maker's preference.

4.4 Method

4.4.1 Data Description

The data for this study comes from the Health and Retirement Study (HRS), which is a biennial longitudinal survey of Americans aged 51 and older since 1992. The present study analyzes all cohorts of respondents who participated in the HRS from 1992 to 2012. The sample is an unbalanced longitudinal data limited to those who responded to the subjective survival probability (SSP) questions.

4.4.2 Measure of Subjective Survival Probability

The HRS collects extensive information on individual expectations, which helps better understand inter-temporal decision making. From the first survey in 1992, the respondents were repeatedly asked to choose a probability figure that best represents their perceived likelihood of occurrence on certain events. Such questions were given on survival, retirement, inflation, stock market performance, unemployment, housing prices, and health limitations, which involves some uncertainty.[8] This survey module is developed given the assumption that individuals have some beliefs about how likely future events will happen in certain period, and base their judgments and decisions on such probabilities (Hurd, 2009). For instance, individuals may have own evaluations about their health conditions, and such private information can be used to update their inferences about the expected age at death (Hurd & McGarry, 2002). Their life-cycle behaviors would then depend more on such subjective judgments, regardless of whether expected probabilities of death coincide with actual likelihood of death.

Among different domains of probabilistic assessment, self-reported probability of living to a certain age has drawn renewed interest from the literature due to its predictive validity of life expectancy (Hurd & McGarry, 1995; 2002). To elicit the subjective living horizon, the survey asked the respondents to report their self-assessed probability of reaching a target age. The default target age is set at age 75 and 85, but also varied based on the age of respondent at interview. Before they respond to the first survival probability question, the following information was provided to help the respondents with probabilistic thinking:

Next we would like to ask your opinion about how likely you think various events might be. When I ask a question I'd like for you to give me a number from 0 to 100, where "0" means

[8] For instance, the respondents were asked to report the probability of working full-time until a certain age, having a work-limiting health problems in the next decade, or leaving a bequest depending on the eligibility criterion.

that you think there is absolutely no chance, and "100" means that you think the event is sure to happen.

The respondents were then asked to respond to the following questions by providing a probabilistic figure between 0 and 100:

What is the percent chance that you will live to be 75 or more? (SSP75+) *And how about the chances that you will live to be 85 or more?* (SSP80-100)[9]

From the 1994 to 1998 survey, the first and second question is limited to those who were younger than 65 and 75 at interview to accommodate more older respondents. Since the 2000 wave, the wording of question depends on the age at the time of interview. Hence, the question is asked in the following format:

How sure are you that you are going to live to be X year or more?

, where X denotes a target age as in Table 4.1.

Table 4.1: Structure of Subjective Survival Probability Questions

Age at Interview	Target Age
50-64	75
65-69	80
70-74	85
75-79	90
80-85	95
85-89	100

The literature found that the SSP varies with known risk factors that affect life horizon. For instance, respondents with chronic conditions or those who smoke and/or drink alcoholic beverages reported relatively low SSP, whereas those with high socio-economic status reported high SSP (Hurd & McGarry, 1995; Manski, 2004). The SSP is adjusted downward when a chronic disease is diagnosed, indicating the presence of Bayesian updating process

[9]Note that the target respondents of SSP75+ are different from SSP80-100. The SSP80-100 is presented to relatively older respondents.

among the respondents (Hurd & McGarry, 2002). The younger elderly, in general, tend to underestimate the SSP while the older elderly are likely to overestimate the SSP (Perozek, 2008). Despite the measurement errors, the subjective mortality rates drawn from such survey responses were quite consistent with the life table values, and the models based on SSP explained life-cycle behaviors more effectively than those using population probabilities (Gan et al., 2004).

An important feature of subjective probability questions is high inflation of responses at focal points - that is, responses of 0, 50, and 100 (Bloom, Canning, Moore, & Song, 2006). According to the literature, most individuals respond to SSP75+ and SSP80-100 questions with 50, followed by 100 and 0. The prevalence of 0 and 100 estimates may represent rounding errors of those who are under-confident or overconfident about their health conditions, or may capture general pessimism or optimism towards the future events. The respondents who are unsure about their life horizon or cannot form a probabilistic judgment would choose 50, which indicates "only god knows" (Hurd, 2009). In this regard, the SSP is measured with errors that may capture psychological biases or lack of understanding in Bayesian reasoning.

The primary variable of interest in this study is the self-assessed probability of living to age 75. While Hurd, Smith, and Zissimopoulos (2004) recommended using the probability of living to age 80-100 which has a greater dispersion and fewer focal responses, I focus on SSP75+ to study younger respondents whose decisions to hold or not to hold risky assets is of greater importance. I also estimate the models with SSP80-100, in order to test how association varies at a later stage of life and whether the findings remain robust.

4.4.3 Portfolio Choice

The HRS contains detailed information on ownership and amounts held in each asset categories. For financial wealth, the respondents were asked to report the net amounts held in the following categories: (a) stocks, mutual funds, and investment trusts; (b) checking, savings, or money market accounts; (c) CD, government savings bonds, and T-bills; (d) bonds and bond funds; and (e) other savings. A net household financial asset is defined as the sum of cash equivalents, bonds, stocks, and other liquid financial assets less debt (Rosen & Wu, 2004). The HRS respondents were instructed to exclude any assets held in retirement accounts, and thus financial asset represents the total value of the household financial asset outside the retirement account. While the retirees put a significant amount of wealth into retirement accounts, I focus only on the portion that households have direct control and is measured with less reporting errors (Love & Smith, 2010). A measure of particular interest is the proportion of financial wealth held in stock, which divides the net value of stocks, stock mutual funds, and investment trusts by total financial assets. I also define a binary indicator of risky asset ownership, which assigns 1 to those who own any stocks or stock mutual funds, and 0 to those with no stocks. These measures allow me to examine whether the variation in portfolio allocation is attributable to relatively minor adjustments between pre-existing assets or major adjustments through the ownership changes.

4.4.4 Empirical Specification

The empirical framework models the extent to which SSP of the financial respondent (FR) and non-financial respondent (NFR) associate with the riskiness of portfolio, which is represented by (a) the proportion of financial wealth allocated to risky assets and (b) risky asset ownership. The primary model then estimates the following linear specification using OLS:

$$y_{i,t} = \Omega + \alpha_1 SSP^f_{i,t} + \alpha_2 SSP^n_{i,t} + \mathbf{X^f_{i,t}}\boldsymbol{\beta^f} + \mathbf{X^n_{i,t}}\boldsymbol{\beta^n} + \varepsilon_{i,t} \tag{4.7}$$

, where $SSP^f_{i,t}$ and $SSP^n_{i,t}$ denote the SSP of FR and NFR, respectively; $\mathbf{X^f_{i,t}}$ and $\mathbf{X^n_{i,t}}$ are covariate matrices that include demographic and other control variables for both types of respondents; α_1, α_2, $\boldsymbol{\beta^f}$, and $\boldsymbol{\beta^n}$ are corresponding parameters; and $\varepsilon_{i,t}$ is an $i.i.d.$ normal error. Demographic variables include age, gender, ethnicity, educational attainment, marital status, onsets of chronic diseases, depression, retirement status, and logged household income and total net worth. Onsets of chronic conditions are measured with a set of binary indicators of high blood pressure, diabetes, cancer, and other health problems, all of which seem to be correlated with the SSP. Note that holding health conditions constant is important in this study because subjective lifespan significantly decreases with chronic conditions (Hurd & McGarry, 1995; 2002). The data on S&P 500 index is obtained from the FRED Economic Data of Federal Reserve Bank of St. Louis, and merged with the analytic sample according to the interview date. This measure, in conjunction with year fixed effects, is expected to net out the variation due to economic cycle effect. The models also include region fixed effects (i.e., census division) to account for any unobserved region-specific tastes towards risky investments.

While the literature has commonly used linear models for modeling portfolio choice, such approach is inappropriate because the response is a proportion restricted between 0 and 1. If the OLS is used to model proportion, the fitted values occasionally exceed it's lower and upper bounds, and the error-variance is heteroskedastic if certain boundary values are reported more frequently.[10] These problems, if present, imply that the OLS estimates are no longer consistent and most efficient among the linear unbiased estimators. A possible solution is to transform the mean of linear model using an appropriate link function that generates values between zero and one. The fractional logit model (Papke & Wooldridge, 1996) is an example that used such transformation, in which the idea is essentially equivalent to transforming binary responses using logit or standard normal cumulative distribution function (CDF). Papke and Wooldridge's formulation assumed a generalized linear model (GLM) with a binomial distribution and a logit link function. That is, the expected value of $y_{i,t}$ can be represented as:

$$E(y_{i,t}) = \Lambda(\Omega + \alpha_1 SSP^f_{i,t} + \alpha_2 SSP^n_{i,t} + \mathbf{X^f_{i,t}}\boldsymbol{\beta^f} + \mathbf{X^n_{i,t}}\boldsymbol{\beta^n}) \tag{4.8}$$

[10]Note that most of the proportion data on portfolio choice includes a large number of zeros and ones.

, where $\Lambda(\cdot)$ is logistic CDF. This approach not only confines the values to a zero-one interval but also stabilizes error variance using a logit-type transformation. Following the methods of McCullagh and Nelder (1989), this equation is estimated by maximizing the Bernoulli log-likelihood function.

While the GLM approach addresses the problems of non-normality and heteroskedastic variance, such approach is still limited in that both bounded and non-bounded values are assumed to follow the same data generating process (DGP). This feature of GLM approach is particularly unattractive if the DGP of boundary values is significantly different from the DGP of nonzero values. In this study, it is fairly likely that certain groups of individuals almost always stay away from risky assets due to some unobserved reasons (e.g., personality traits), while others who have no incentive to hold risky assets still invest in stocks. Although the fractional logit corrects distributional characteristics of response, it does not allow for an alternative DGP that generates the limit values.

As an additional empirical advancement, I consider two-part models that postulate a different DGP for discretely and continuously distributed random variables. I utilize the zero-inflated beta (ZIB) model (Cook, Kieschnick, & McCullough, 2008), which consists of two parts: (a) a logit model for a binary outcome; and (b) a beta regression for non-zero fractional responses. The two-part model is very flexible as the DGP for a continuous random variable could follow any suitable probability distributions. In theory, the second part regression can be any estimator that fits the non-boundary values most. In this study, I assume the beta distribution which is essentially a two-parameter function that accommodates skewness and bimodality of portfolio choice outcomes (Ferrari & Cribari-Neto, 2004).

It is important to note that Heckman selection model (Heckman, 1977), which has been widely employed in the portfolio choice studies, is essentially a two-part model. Unlike other two-part models, Heckman model is not properly identified without appropriate exclusion restrictions for the selection process. That is, if correctly specified the Heckman model lends themselves to a more explicit causal approach while correcting selection bias using inverse

Mills ratio. This makes Heckman model particularly attractive for a study of portfolio choice because people make participation and allocation decision independently. In the last section of empirical analysis, I re-examine the issues by estimating Heckman two-step model. To achieve identification, I follow Fagereng et al. (2015) where a lagged net worth is suggested as an exclusion restriction for stock market participation. For consistency, the first and second stage regression is estimated by logit and two-parameter beta regression. The second stage standard errors are bootstrapped with 100 replications.

4.5 Results

4.5.1 Descriptive Analysis

Table 4.2 presents the summary statistics. The sample characteristics are arrayed by bargaining power, as well as their role in the marital relationship (i.e., husband vs. wife). The financial respondent (FR) is supposed to be the one who is most knowledgeable and has more control over financial resources within the household. In a typical household, it is commonly believed that the older spouse is more likely to be a decision-maker, and thus impose a greater weight on family money matters (Bertocchia, Brunetti, & Torricelli, 2012).

In my data, the mean age of financial respondents is 57.9 for husbands and 54.9 for wives, which is greater than 57.0 and 54.2 of non-financial respondents (NFR). The differences in mean age between FRs and NFRs within both gender groups are significant at the 1% significance level. Among married men, both SSP75+ and SSP80-100 are greater for the FRs. This is somewhat surprising because those with bargaining power are older than those with no “final say”. There is a significant difference between FR’s and NFR’s SSP75+, while such difference in SSP80-100 is not significant at the 10% level. Interestingly, the pattern is reversed for married women. Note that both SSP75+ and SSP80-100 are significantly greater for the wives with bargaining power, which conforms to the age difference between FRs and NFRs. The SSP of married men is clearly lower than married women, regardless of the measure of SSP and bargaining power. This is in support for the previous findings that

SSP indeed captures the perceived lifespan of individuals (Hurd, 2009). I also find a strong evidence that a spouse who earns more is likely to be a FR, although such pattern is less obvious with the education background.

4.5.2 Regression Results: Unitary Models

Before presenting the bargaining outcomes, I first examine the impact of SSP on family portfolio choice assuming a unitary model. While the issue of portfolio choice and subjective live expectancy is explored in Speanjers and Spira (2015), their findings are limited due to the cross-sectional nature of data and measurement error in subjective life horizon. In their study, subjective life horizon is defined by subtracting the age at interview from expected age at death, which is measured directly by a survey question *"About how old do you think you will live to be?"*. The mean age at interview was about 50, and the average subjective horizon was 32 years, indicating that the respondents were far ahead of retirement age. Although their estimates of subjective life horizon vary with other life-cycle components, the assumption that people can predict the occurrence of events 30 years in advance seems quite unrealistic. For those in late 40's or early 50's, predicting age at death would be a challenging task because most people at that point of life-cycle enjoy relatively good health. Thus, their responses could be rough guesses, which is not strictly based on the assessment of relevant (private) information. Also, the wording of survey question does not exploit probabilistic assessment that could force the respondents to form Bayesian inferences. My study is different in that subjective life horizon is measured by the subjective probability of survival to age 75 or 80-100, which is asked to those around 55-58 years old.

Table 4.3 through 4.6 present the regression results of the unitary models. The proportion of financial assets held in cash equivalents, risk-free assets, bonds, and stocks, are assumed to capture how a financial portfolio is allocated between risky and non-risky assets. Results reported in Table 4.3 show that SSP75+ is associated with a smaller share of cash or risk-free assets, while such associations are positive with the share of bonds or stocks. For instance, a

10 percentage points increase in SSP75+ is associated with about 0.35 and 0.11 percentage points decrease in the proportion of cash and risk-free assets, respectively. A similar increase in SSP75+ leads to 6 and 21 basis points greater share of bonds and stocks. Although the estimate of SSP75+ is statistically significant in column (2) and (3), these associations do not seem quantitatively meaningful.

Table 4.4 shows the regression results from alternative specifications. Panel A estimates the impact of SSP75+ using the fractional logit model. Consistent with the previous estimation results, the associations remain significant at 1%, but the magnitudes of estimates are slightly inflated. For instance, a 10 percentage points increase in SSP75+ is associated with 0.46 percentage points less proportion of cash and 0.29 percentage points greater share of stocks. Panel B presents the estimates from two-stage least squares (2SLS) methods. The instruments for subjective survival probability are parents' mortality outcomes such as current age or age at death (Bloom et al., 2006). The 2SLS estimates of SSP75+ are significant in column (1), (2), and (4) and generally greater in magnitude. In particular, column (4) shows that a 10 percentage points increase in SSP75+ is associated with 0.86 percentage points greater financial wealth allocated to stocks. The significance of this estimate indicates that the effect of SSP75+ can be interpreted as a causal relationship. It is important to note that the regressor of interest is still an imperfect proxy for subjective life expectancy. Such proxy measured with error is subject to attenuation bias, and thus the estimates from OLS and fractional logit are plausibly the lower bound of true relationship. The IV models in panel C correct the attenuation bias using a lagged SSP75+ as an instrument. For identification, I assume that measurement error is uncorrelated over time, and thus the predicted SSP75+ from the first stage regression captures only the systematic component (Griliches & Hausman, 1986). The 2SLS estimates in panel C are about two or three times greater than fractional logit but also smaller than panel B. Column (1) and (4), for instance, show that a 10 percentage points increase in SSP75+ is associated with 1.17 percentage points smaller and 0.75 percentage points greater share of cash and stocks in financial assets.

Tables 4.5 and 4.6 present the impact of SSP80-100 by estimating the same models as in Tables 4.3 and 4.4. Since the respondents who answered SSP80-100 are older than those who responded to SSP75+, the magnitude of associations are expected to be smaller. In Table 4.5, a 10 percentage points increase in SSP80-100 is associated with 0.28 decrease in the ratio of cash to financial assets and 0.19 increase in the ratio of stocks to financial assets. As expected, the coefficient estimates on SSP80-100 are smaller. Table 4.6 also present similar findings as above. It appears the effect of SSP80-100 is also causal, and the original estimates are attenuated due to measurement error. In this case, however, the estimates in panel C are quite close to those in Table 4.5, which implies the respondents could answer SSP80-100 questions with greater precision. This might be because individuals have more health-related information at the later stage of life-cycle, and thus predict living horizon more precisely.

4.5.3 Regression Results: Bargaining Models

In the remaining section, I present the estimation results of bargaining models. Table 4.7 estimates the impact of SSP75+ of both FR and NFR on the proportion of financial assets held in stocks using OLS. Column (1) is the null model where the response is regressed only on the SSP75+ of the FR. Column (2) further develops the model by conditioning upon FR's characteristics and household income and net worth. Across the first two models, I find a positive association between the SSP75+ of FR and the riskiness of portfolio. Column (3) shows the extent to which the SSP75+ of NFR vary with portfolio allocation. The share of stocks increases by 0.17 percentage points with a 10 percentage points rise in NFR's SSP75+, conditioned upon this spouse' characteristics. The association is significant at the 1% level, but slightly smaller than SSP75+ of the FR in column (2). Column (4) estimates the fully specified model, which is the preferred specification of this study. This model regresses the riskiness of portfolio on SSP75+ of both spouses, conditioned upon their characteristics. In this model, about 20 basis points increase in the share of risky assets is attributable to a

10 percentage point increase in the SSP75+ of the FR, while NFR's SSP has no significant impact on portfolio allocation.

Column (5) shows interesting interactions between bargaining power and gender role in marriage. When wife is a FR, I find that the riskiness of portfolio significantly increases with the wife's probability of survival beyond age 75 (H_0: β_1+β_4=0). Husband's SSP, however, has no discernible impact on asset allocation, under the influence of wife (H_0: β_2+β_5=0). Specifically, when wife has more bargaining power, about 0.14 percentage points increase in the share of stock is attributable to a 10 percentage points rise in wife's SSP. Such association is not significant with the SSP of husband at the 10% level. In turn, portfolio allocation is much more responsive to the changes in a wife's expected horizon than a husband's, among the families in which wife has the "final say" (H_0: $\beta_1 + \beta_4$=$\beta_2 + \beta_5$). It is also interesting to note that the impact of FR's SSP is significant regardless of their gender (H_0: β_4=0), while the influence of NFR's SSP is markedly small when such NFR is husband (H_0: β_5=0). This pattern shows an interesting twist due to gender effects, which was previously reported in Friedberg and Webb (2006).

Table 4.8 re-estimates the models in column (4) and (5) of Table 4.7 using fractional logit, zero-inflated beta, and Heckman models. Column (2) of panel A shows the marginal effects from fractional logit that re-fits column (4) of Table 4.7. As observed in the unitary models, fractional logit model generates a larger estimate of SSP. The SSP75+ of NFR seems to have a significant impact on portfolio choice, but its influence is smaller than that of FR. An interaction of SSP75+ of NFR with whether the FR is female is significant at the 5% in column (3). Panel B allows me to separate the impact of SSP on portfolio composition from the stock ownership decisions. In the zero-inflated model, SSP75+ of FR has a positive impact on the stock ownership, and this is independent of whether the FR is wife or husband. The impact of SSP75+ on the nonzero proportion outcome remains the same as before. Heckman models presented in panel C re-fit the two-part models from panel B but with the exclusion restriction. The lagged net worth is used as an exclusion restriction that determines the stock ownership of individuals (Fagereng et al., 2015). Again, the impact of FR's SSP75+ is dominant across the models. Consistent with previous findings, the impact of NFR's SSP75+ is moderated by whether the FR is wife. In Heckman model, however, the estimate of the interaction term is only marginally significant. Note also that IMR is significantly associated with a response, indicating the presence of self-selection bias in the previous models.

Results presented in Tables 4.9 re-fit the models using SSP80-100 as a regressor. As in unitary models, the impact of SSP80-100 is smaller than SSP75+ across all specifications. In column (4), the impacts of FR and NFR's SSP80-100 are not significantly different from each other, which is in contrast to the previous estimates with SSP75+. Column (5) shows the similar pattern of bargaining power-gender interactions as in Table 4.7. With the probability of survival to 80-100 age and wife as a FR, I find that more financial wealth is allocated to stocks the higher is the wife's SSP but not the husband's (H_0: $\beta_1+\beta_4=0$). When wife is a FR, the influence of husband's SSP is nearly nonexistent (H_0: $\beta_2+\beta_5=0$). According to the estimates, approximately 0.17 percentage points greater share of stock is associated with a 10 percentage points higher SSP of wife. With husband's SSP, such association is not only very close to 0 but also statistically insignificant at the 10% level. Again, portfolio allocation is much more responsive to the changes in a wife's expected horizon than a husband's, among the families in which wife has the "final say" (H_0: $\beta_1 + \beta_4=\beta_2 + \beta_5$). Note that the estimate on β_4 is not significant, while $\widehat{\beta_5}$ is significant at the 10% level. This, again, indicates that a decision maker's gender does not matter when it comes to the impact of FR's SSP on portfolio choice. Much less pronounced effect of SSP80-100 among non-decision making husbands shows an interesting twist due to gender role in marriage.

Table 4.10 also shows the same patter an in Table 4.8. In this case, however, the impact of NFR's SSP80-100 is not significant in Panel A and B. Only Heckman model in Panel C shows the significant association between the NFR's SSP80-100 and risky asset share. Overall, the associations are less clear and somewhat inconclusive with SSP80-100.

Table 4.11 verifies the robustness of findings. While the SSP is assumed to capture the expected living horizon, it could simply proxies for their confidence in health status or more general optimism towards future. To test such arguments, column (2) includes both spouse's self-reported health conditions captured by 5-category self-assessed physical health. I find that about one-fourth of the association between the SSP and outcome is absorbed here. The measure of SSP indeed captures some information on the perceived health condition, but does not significantly alter the findings. Column (3) and (4) account for expectations regarding retirement income and retirement living standards. They all inflate the impact of SSP on the riskiness of portfolio, but the estimates of interest remain significant. Finally, I control for all these confounding factors in column (6), but find no significant difference.

4.6 Conclusion

Building upon the cooperative bargaining framework, I examine the association between the share of financial wealth allocated to risky assets and husbands and wife's life expectancy. The theoretical framework provides two important predictions. First, the riskiness of portfolio increases with a difference in life expectancy between a decision maker and non-decision maker. Second, the share of financial wealth allocated to risky assets grows with the bargaining power of spouse who faces longer horizon.

The empirical investigation utilizes survey questions on subjective survival probability in the HRS as proxies for individuals' subjective life expectancy. The spouses' relative bargaining power is measured by a dichotomous variable identifying a financial respondent presumably a person with greater knowledge and influence on the familys financial decisions. The riskiness of portfolio is represented by two measures: (a) the proportion of risky assets held in equities; and (b) whether a family holds any equities. For empirical advancement, a binary data generation process of risky asset ownership and a continuous data generation process of portfolio composition are jointly modeled.

My empirical findings are in line with the predictions from the theoretical framework. First, I found that the share of risky assets is more sensitive to the subjective survival probability of financial respondent than non-financial respondent. The subjective survival probability of non-financial respondent also has a significant impact on portfolio choice, but its impact is much smaller. Second, there is an interesting interaction between gender and bargaining power that affects portfolio choice. When husbands have more bargaining power, I find that risky asset share increases with the subjective lifespan of both spouses, and when wives have the "final say" only wives' subjective lifespan affects portfolio allocation. The impact of financial respondent's subjective lifespan is significant regardless of their gender, while the influence of non-financial respondent's subjective lifespan is markedly small when such person is husband. Collectively, these findings further support our hypothesis that a family portfolio is formed (or, reallocated) in favor of the spouse with more bargaining power.

Although only a few assumptions are made in the framework, my predictions and empirical findings build strictly upon the independence of bargaining power. That is, facing significantly different lifespan is assumed to have no influence on losing or taking over the "final say". This issue is important because the collinearity of subjective survival probability with financial respondent status biases the impact of subjective horizon. For instance, if a spouse facing longer horizon takes over the "final say", my estimates of the subjective survival probability would be downward biased.

The measurement error of the sharing rule constitutes another limitation of the study. As discussed above, bargaining power is not easily measured, and thus a binary measure of the financial respondent status is at best a crude and noisy proxy. While previous studies employed several different measures of bargaining power to check the robustness, only a measure of financial respondent was compatible with this study's sample selection, and hence other measures could not be considered.

It is also important to note that the measurement error of subjective life expectancy is not adequately addressed in the bargaining models. While the unitary models exploit the longitudinal structure of data or parental mortality conditions to account for measurement errors, bargaining models could not employ the same identification strategies due to its impact on covariance structure. My estimation results from the unitary models imply that the estimates of bargaining models could be significantly underestimated.

Table 4.2: Descriptive Statistics

	Non-Financial Respondent	Financial Respondent	Full Sample
Husband			
Age	57.0	57.9	57.6
SSP 75+ (%)	61.7	64.1	63.3
SSP 80-100 (%)	41.7	42.3	42.1
Annual earnings§	$24,547	$36,300	$31,601
Share of earnings (%)	53.7	62.6	59.4
Hold college degree (%)	16.6	33.4	27.5
Wife			
Age	54.2	54.9	54.4
SSP 75+ (%)	67.8	66.3	67.3
SSP 80-100 (%)	50.0	48.2	49.4
Annual earnings§	$12,155	$16,365	$13,333
Share of earnings (%)	37.5	46.2	40.6
Hold college degree (%)	23.3	19.4	22.0
Share of risky assets (%)			18.6
Hold risky assets (%)			34.0
Financial wealth§			$14,585
Non-housing wealth§			$85,589
Observations			48,025

Notes: This table presents the summary statistics of analytic sample. "Share of risky assets" represents the proportion of financial wealth held in stocks, mutual funds, and investment trusts. The financial wealth is the net value of non-housing financial wealth, which is a sum of checking acocunts, government and corporate bonds, stocks and stock-oriented mutual funds, and other savings less short-term debts. The non-housing financial wealth is the sum of financial wealth, net value of vehicles, businesses, real estate (not primary residence), and retirement accounts. All dollar figures are adjusted to 2012 dollars using the Consumer Price Index for all urban consumers (CPI-U). To account for the skewness of dollar amounts, median values are reported for income and wealth and denoted by §.

Table 4.3: Models for Portfolio Choice: SSP75+

Dependent Variable:	(1) Cash / FA OLS	(2) Risk-Free / FA OLS	(3) Bonds / FA OLS	(4) Stocks / FA OLS
SSP75+ (/10)	**-0.0035*** **	**-0.0011*** **	**0.0006*** **	**0.0021*** **
	(0.0007)	**(0.0004)**	**(0.0002)**	**(0.0006)**
Age	-0.0035***	0.0020***	0.0006***	0.0017***
	(0.0004)	(0.0002)	(0.0001)	(0.0003)
Female	-0.0109**	0.0049**	0.0021**	0.0061
	(0.0047)	(0.0025)	(0.0009)	(0.0038)
Non-Hispanic White	-0.0730***	0.0049	0.0042***	0.0544***
	(0.0079)	(0.0041)	(0.0016)	(0.0064)
Non-Hispanic Black	0.0597***	-0.0087*	0.0009	-0.0272***
	(0.0100)	(0.0052)	(0.0021)	(0.0081)
High school graduate	-0.0970***	0.0211***	0.0037**	0.0506***
	(0.0074)	(0.0039)	(0.0015)	(0.0060)
Some college	-0.1536***	0.0143***	0.0073***	0.0877***
	(0.0080)	(0.0041)	(0.0016)	(0.0064)
College graduate	-0.2308***	0.0065	0.0175***	0.1522***
	(0.0082)	(0.0043)	(0.0017)	(0.0066)
High blood pressure	0.0103**	0.0006	-0.0014	-0.0101***
	(0.0043)	(0.0023)	(0.0009)	(0.0035)
Diabetes	0.0255***	-0.0061*	-0.0028**	-0.0188***
	(0.0061)	(0.0032)	(0.0014)	(0.0050)
Cancer	-0.0082	0.0056	0.0020	-0.0039
	(0.0076)	(0.0040)	(0.0017)	(0.0062)
Heart problem	0.0115*	-0.0082***	-0.0013	-0.0081*
	(0.0059)	(0.0031)	(0.0013)	(0.0049)
CES-D score	-0.0003	-0.0010*	0.0004	-0.0005
	(0.0011)	(0.0006)	(0.0003)	(0.0009)
Retired	-0.0025	0.0022**	0.0014***	0.0027*
	(0.0019)	(0.0010)	(0.0005)	(0.0016)
Log(HH income)	-0.0193***	0.0021***	0.0017***	0.0138***
	(0.0013)	(0.0007)	(0.0003)	(0.0011)
Log(Total net worth)	-0.0124***	0.0017***	0.0009***	0.0073***
	(0.0003)	(0.0002)	(0.0001)	(0.0003)
S&P500 (/100)	-0.0067***	0.0019	0.0005	0.0024
	(0.0025)	(0.0013)	(0.0007)	(0.0021)
R^2	0.160	0.026	0.018	0.111
Observations	47,813	47,813	47,813	47,813

Notes: The dependent variables are non-housing financial wealth held in each asset category. Specifically, cash represents the value of checking, savings, or money market accounts while savings represents the value of CD, government savings bonds, and T-bills. Bonds and stocks represent the net value of bonds and bond funds, and the net value of stocks, mutual funds, and investment trusts, respectively. Standard errors are reported in parentheses. Each regression model includes S&P 500 index, Census division dummies and year dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 4.4: Models for Portfolio Choice: SSP75+, Alternative Specifications

	(1)	(2)	(3)	(4)
Dependent Variable:	Cash / FA	Risk-Free / FA	Bonds / FA	Stocks / FA
Panel A: Fractional Logit (marginal effects)				
SSP75+ (/10)	**-0.0046*****	**-0.0014*****	**0.0006*****	**0.0029*****
	(0.0008)	**(0.0004)**	**(0.0002)**	**(0.0007)**
Age	-0.0030***	0.0019***	0.0004***	0.0012***
	(0.0004)	(0.0002)	(0.0001)	(0.0004)
Observations	47,813	47,813	47,813	47,813
Panel B: 2SLS - Accounting for focal point bias				
SSP75+ (/10)	**-0.0188*****	**0.0050***	**0.0012**	**0.0086***
	(0.0058)	**(0.0030)**	**(0.0011)**	**(0.0048)**
Age	-0.0030***	0.0018***	0.0006***	0.0015***
	(0.0004)	(0.0002)	(0.0001)	(0.0003)
R^2	0.152	0.019	0.018	0.110
Observations	47,813	47,813	47,813	47,813
Panel C: 2SLS - Accounting for attenuation bias				
SSP75+ (/10)	**-0.0117*****	**-0.0008**	**0.0006**	**0.0075*****
	(0.0030)	**(0.0014)**	**(0.0006)**	**(0.0027)**
Age	-0.0032***	0.0018***	0.0005***	0.0018***
	(0.0005)	(0.0003)	(0.0001)	(0.0004)
R^2	0.162	0.021	0.017	0.112
Observations	32,171	32,171	32,171	32,171

Notes: Panel A presents the marginal effects estimates of fractional logit models. Panel B presents the two-step estimation results that correct focal point bias by instrumenting SSP75+ using parents' mortality outcomes. Panel C presents the two-step estimation results that instrument SSP75+ using the lag of SSP75+, assuming that measurement error is uncorrelated over time. Standard errors are reported in parentheses. Each regression model includes demographic covariates, household economic conditions, S&P 500 index, Census division dummies, and year dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 4.5: Models for Portfolio Choice: SSP80-100

Dependent Variable:	(1) Cash / FA OLS	(2) Risk-Free / FA OLS	(3) Bonds / FA OLS	(4) Stocks / FA OLS
SSP80-100 (/10)	**-0.0028***** **(0.0006)**	**-0.0008**** **(0.0003)**	**0.0002*** **(0.0001)**	**0.0019***** **(0.0005)**
Age	-0.0037*** (0.0003)	0.0025*** (0.0002)	0.0006*** (0.0001)	0.0019*** (0.0003)
Female	-0.0123*** (0.0045)	0.0067*** (0.0023)	0.0024*** (0.0009)	0.0075** (0.0036)
Non-Hispanic White	-0.0794*** (0.0075)	0.0070* (0.0039)	0.0047*** (0.0015)	0.0553*** (0.0061)
Non-Hispanic Black	0.0585*** (0.0096)	-0.0083* (0.0050)	0.0009 (0.0020)	-0.0293*** (0.0077)
High school graduate	-0.0980*** (0.0069)	0.0233*** (0.0036)	0.0024* (0.0014)	0.0515*** (0.0056)
Some college	-0.1547*** (0.0075)	0.0130*** (0.0039)	0.0069*** (0.0015)	0.0903*** (0.0060)
College graduate	-0.2359*** (0.0077)	0.0037 (0.0040)	0.0191*** (0.0015)	0.1590*** (0.0062)
High blood pressure	0.0101*** (0.0039)	-0.0010 (0.0021)	-0.0024*** (0.0009)	-0.0081** (0.0032)
Diabetes	0.0266*** (0.0053)	-0.0088*** (0.0029)	-0.0018 (0.0012)	-0.0179*** (0.0044)
Cancer	-0.0062 (0.0063)	0.0046 (0.0034)	0.0014 (0.0014)	-0.0011 (0.0052)
Heart problem	0.0100** (0.0051)	-0.0057** (0.0027)	-0.0019 (0.0011)	-0.0089** (0.0042)
CES-D score	0.0005 (0.0010)	-0.0010* (0.0006)	0.0003 (0.0003)	-0.0009 (0.0008)
Retired	-0.0010 (0.0017)	0.0026*** (0.0010)	0.0018*** (0.0004)	0.0012 (0.0014)
Log(HH income)	-0.0195*** (0.0012)	0.0019*** (0.0007)	0.0022*** (0.0003)	0.0144*** (0.0010)
Log(Total net worth)	-0.0124*** (0.0003)	0.0020*** (0.0002)	0.0010*** (0.0001)	0.0074*** (0.0003)
S&P500 (/100)	-0.0054** (0.0023)	0.0015 (0.0013)	-0.0000 (0.0006)	0.0026 (0.0019)
R^2	0.165	0.030	0.021	0.114
Observations	58,920	58,920	58,920	58,920

Notes: The dependent variables are non-housing financial wealth held in each asset category. Specifically, cash represents the value of checking, savings, or money market accounts while savings represents the value of CD, government savings bonds, and T-bills. Bonds and stocks represent the net value of bonds and bond funds, and the net value of stocks, mutual funds, and investment trusts, respectively. Standard errors are reported in parentheses. Each regression model includes S&P 500 index, Census division dummies and year dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 4.6: Models for Portfolio Choice: SSP80-100, Alternative Specifications

	(1)	(2)	(3)	(4)
Dependent Variable:	Cash / FA	Risk-Free / FA	Bonds / FA	Stocks / FA
Panel A: Fractional Logit (marginal effects)				
SSP80-100 (/10)	**-0.0028*** **	**-0.0013*** **	**0.0001**	**0.0017*** **
	(0.0007)	**(0.0004)**	**(0.0002)**	**(0.0006)**
Age	-0.0035***	0.0025***	0.0005***	0.0013***
	(0.0004)	(0.0002)	(0.0001)	(0.0003)
Observations	58,920	58,920	58,920	58,920
Panel B: 2SLS - Accounting for focal point bias				
SSP80-100 (/10)	**-0.0130*** **	**0.0028**	**0.0008**	**0.0078** **
	(0.0046)	**(0.0024)**	**(0.0010)**	**(0.0038)**
Age	-0.0032***	0.0023***	0.0006***	0.0016***
	(0.0004)	(0.0002)	(0.0001)	(0.0003)
R^2	0.159	0.026	0.021	0.111
Observations	58,920	58,920	58,920	58,920
Panel C: 2SLS - Accounting for attenuation bias				
SSP80-100 (/10)	**-0.0039***	**-0.0037*** **	**0.0001**	**0.0045** **
	(0.0022)	**(0.0011)**	**(0.0004)**	**(0.0020)**
Age	-0.0038***	0.0027***	0.0006***	0.0019***
	(0.0004)	(0.0002)	(0.0001)	(0.0003)
R^2	0.167	0.026	0.021	0.114
Observations	41,260	41,260	41,260	41,260

Notes: Panel A presents the marginal effects estimates of fractional logit models. Panel B presents the two-step estimation results that correct focal point bias by instrumenting SSP80-100 using parents' mortality outcomes. Panel C presents the two-step estimation results that instrument SSP80-100 using the lag of SSP80-100, assuming that measurement error is uncorrelated over time. Standard errors are reported in parentheses. Each regression model includes demographic covariates, household economic conditions, S&P 500 index, Census division dummies, and year dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 4.7: Bargaining Models for the Share of Risky Assets: SSP75+

	(1)	(2)	(3)	(4)	(5)
Dependent Variable:			Stocks / FA		
	OLS	OLS	OLS	OLS	OLS
β_1: **SSP75+$_{FR}$ (/10)**	**0.0065*****	**0.0024*****		**0.0020*****	**0.0026*****
	(0.0005)	**(0.0005)**		**(0.0005)**	**(0.0006)**
β_2: **SSP75+$_{NFR}$ (/10)**			**0.0017*****	**0.0008**	**0.0017****
			(0.0005)	**(0.0005)**	**(0.0007)**
β_3: FR is female					0.0036
					(0.0095)
β_4: FR is female*SSP75+$_{FR}$ (/10)					-0.0012
					(0.0010)
β_5: FR is female*SSP75+$_{NFR}$ (/10)					-0.0024**
					(0.0010)
FR's characteristics	No	Yes	No	Yes	Yes
NFR's characteristics	No	No	Yes	Yes	Yes
HH economic conditions	No	Yes	Yes	Yes	Yes
R^2	0.040	0.134	0.128	0.141	0.141
Observations	47,409	47,409	47,409	47,409	47,409
Linear restrictions (z-value)					
H_0: β_1+β_4=0					0.0014*
H_0: β_2+β_5=0					-0.0007
Testing the equality of coefficients (p-value)					
H_0: β_1=β_2					0.324
H_0: $\beta_1 + \beta_4$=$\beta_2 + \beta_5$					0.080*

Notes: FR and NFR represent financial respondent and non-financial respondent, respectively. SSP75+$_{FR}$ and SSP75+$_{NFR}$ represent the SSP75+ of financial respondent and non-financial respondent. FR's and NFR's characteristics includes age, race, education background, chronic health conditions, and retirement status of each spouse. Household economic condition includes logged total household income and logged total net worth. Standard errors are reported in parentheses. Each regression model includes S&P 500 index, Census division dummies and year dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 4.8: Bargaining Models for the Share of Risky Assets: SSP75+, Alternative Specifications

	(1)	(2)	(3)
Dependent Variable:		Stocks / FA	
	$\widehat{\beta}$	dy/dx	$\widehat{\beta}$
Panel A: Fractional Logit (marginal effects)			
SSP75+$_{FR}$ (/10)	**0.0216*** **	**0.0029*** **	**0.0232*** **
	(0.0050)	**(0.0007)**	**(0.0059)**
SSP75+$_{NFR}$ (/10)	**0.0105** **	**0.0014** **	**0.0177*** **
	(0.0049)	**(0.0007)**	**(0.0062)**
FR is female			0.0792
			(0.1003)
FR is female*SSP75+$_{FR}$ (/10)			-0.0007
			(0.0106)
FR is female*SSP75+$_{NFR}$ (/10)			-0.0226**
			(0.0098)
Observations	47,409		47,409
Panel B: Zero-Inflated Beta (marginal effects)			
(Proportion model)			
SSP75+$_{FR}$ (/10)	**0.0128*** **	**0.0032*** **	**0.0144*** **
	(0.0047)	**(0.0012)**	**(0.0055)**
SSP75+$_{NFR}$ (/10)	**0.0046**	**0.0011**	**0.0095* **
	(0.0046)	**(0.0011)**	**(0.0057)**
FR is female			0.0494
			(0.0092)
FR is female*SSP75+$_{FR}$ (/10)			-0.0018
			(0.0105)
FR is female*SSP75+$_{NFR}$ (/10)			-0.0164*
			(0.0093)
(Zeroinflate model)			
SSP75+$_{FR}$ (/10)	**-0.0220*** **	**-0.0037*** **	**-0.0248*** **
	(0.0056)	**(0.0009)**	**(0.0066)**
SSP75+$_{NFR}$ (/10)	**-0.0085**	**-0.0014**	**-0.0112**
	(0.0054)	**(0.0009)**	**(0.0070)**
FR is female			-0.0860
			(0.0114)
FR is female*SSP75+$_{FR}$ (/10)			0.0081
			(0.0114)
FR is female*SSP75+$_{NFR}$ (/10)			0.0073
			(0.0108)
Wald χ^2	360.20		373.51
Observations	47,409		47,409
Panel C: Heckman model			
SSP75+$_{FR}$ (/10)	**0.0316*** **	**0.0077*** **	**0.0053*** **
	(0.0065)	**(0.0016)**	**(0.0016)**
SSP75+$_{NFR}$ (/10)	**0.0152** **	**0.0037** **	**0.0025**
	(0.0062)	**(0.0015)**	**(0.0016)**
FR is female			-0.0164
			(0.0268)
FR is female*SSP75+$_{FR}$ (/10)			0.0009
			(0.0028)
FR is female*SSP75+$_{NFR}$ (/10)			-0.0033
			(0.0026)
IMR	1.2380***		0.2233***
	(0.2097)		(0.0390)
Observations	11,338		11,338

Notes: Standard errors are reported in parentheses. Each regression model includes demographic covariates, household economic conditions, S&P 500 index, Census division dummies, and year dummies. IMR denotes inverse Mills ratio. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 4.9: Bargaining Models for the Share of Risky Assets: SSP80-100

	(1)	(2)	(3)	(4)	(5)
Dependent Variable:			Stocks / FA		
	OLS	OLS	OLS	OLS	OLS
β_1: **SSP80-100$_{FR}$ (/10)**	**0.0039*****	**0.0019*****		**0.0015*****	**0.0017*****
	(0.0004)	**(0.0004)**		**(0.0004)**	**(0.0005)**
β_2: **SSP80-100$_{NFR}$ (/10)**			**0.0018*****	**0.0011*****	**0.0015*****
			(0.0004)	**(0.0004)**	**(0.0005)**
β_3: FR is female					-0.0109*
					(0.0062)
β_4: FR is female*SSP80-100$_{FR}$ (/10)					0.0001
					(0.0008)
β_5: FR is female*SSP80-100$_{NFR}$ (/10)					-0.0016*
					(0.0008)
FR's characteristics	No	Yes	No	Yes	Yes
NFR's characteristics	No	No	Yes	Yes	Yes
HH economic conditions	No	Yes	Yes	Yes	Yes
R^2	0.031	0.136	0.129	0.143	0.144
Observations	63,010	63,010	63,010	63,010	63,010
Linear restrictions (z-value)					
H_0: $\beta_1+\beta_4=0$					0.0017**
H_0: $\beta_2+\beta_5=0$					-0.00002
Testing the equality of coefficients (p-value)					
H_0: $\beta_1=\beta_2$					0.854
H_0: $\beta_1+\beta_4=\beta_2+\beta_5$					0.079*

Notes: SSP80-100$_{FR}$ and SSP80-100$_{NFR}$ represent the SSP80-100 of financial respondent and non-financial respondent. FR's and NFR's characteristics includes age, race, education background, chronic health conditions, and retirement status of each spouse. Household economic condition includes logged total household income and logged total net worth. Standard errors are reported in parentheses. Each regression model includes S&P 500 index, Census division dummies and year dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 4.10: Bargaining Models for the Share of Risky Assets: SSP80-100, Alternative Specifications

	(1)	(2)	(3)
Dependent Variable:		Stocks / FA	
	$\widehat{\beta}$	dy/dx	$\widehat{\beta}$
Panel A: Fractional Logit (marginal effects)			
SSP80-100$_{FR}$ (/10)	**0.0122*** **	**0.0017*** **	**0.0129*** **
	(0.0040)	**(0.0005)**	**(0.0048)**
SSP80-100$_{NFR}$ (/10)	**0.0055**	**0.0007**	**0.0095** **
	(0.0039)	**(0.0005)**	**(0.0048)**
FR is female			-0.0050
			(0.0626)
FR is female*SSP80-100$_{FR}$ (/10)			0.0020
			(0.0082)
FR is female*SSP80-100$_{NFR}$ (/10)			-0.0147*
			(0.0081)
Observations	63,010		63,010
Panel B: Zero-Inflated Beta (marginal effects)			
(Proportion model)			
SSP80-100$_{FR}$ (/10)	**0.0078** **	**0.0017*** **	**0.0082***
	(0.0036)	**(0.0005)**	**(0.0043)**
SSP80-100$_{NFR}$ (/10)	**0.0058**	**0.0108**	**0.0095***
	(0.0036)	**(0.0005)**	**(0.0043)**
FR is female			0.0311
			(0.0569)
FR is female*SSP80-100$_{FR}$ (/10)			0.0016
			(0.0073)
FR is female*SSP80-100$_{NFR}$ (/10)			-0.0166**
			(0.0076)
(Zeroinflate model)			
SSP80-100$_{FR}$ (/10)	**-0.0115** **	**-0.0019** **	**-0.0140** **
	(0.0045)	**(0.0009)**	**(0.0057)**
SSP80-100$_{NFR}$ (/10)	**-0.0034**	**-0.0014**	**-0.0035**
	(0.0043)	(0.0009)	(0.0055)
FR is female			-0.0066
			(0.0688)
FR is female*SSP80-100$_{FR}$ (/10)			0.0059
			(0.0091)
FR is female*SSP80-100$_{NFR}$ (/10)			0.0014
			(0.0088)
Wald χ^2	367.39		373.51
Observations	63,010		47,409
Panel C: Heckman model			
SSP80-100$_{FR}$ (/10)	**0.0180*** **	**0.0044*** **	**0.0036*** **
	(0.0045)	**(0.0011)**	**(0.0011)**
SSP80-100$_{NFR}$ (/10)	**0.0127*** **	**0.0031*** **	**0.0033*** **
	(0.0045)	**(0.0011)**	**(0.0011)**
FR is female			-0.0077
			(0.0150)
FR is female*SSP80-100$_{FR}$ (/10)			0.0004
			(0.0019)
FR is female*SSP80-100$_{NFR}$ (/10)			-0.0032*
			(0.0018)
IMR	1.2484***		0.2095***
	(0.1655)		(0.0298)
Observations	17,162		17,162

Notes: Standard errors are reported in parentheses. Each regression model includes demographic covariates, household economic conditions, S&P 500 index, Census division dummies, and year dummies. IMR denotes inverse Mills ratio. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

Table 4.11: Bargaining Models for the Share of Risky Assets: Robustness Check

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Stocks / FA					
	OLS	OLS	OLS	OLS	OLS	OLS
SSP75+$_{FR}$ (/10)	**0.0020******	**0.0015******	**0.0024******	**0.0025******	**0.0020*****	**0.0019*****
	(0.0005)	**(0.0005)**	**(0.0008)**	**(0.0008)**	**(0.0008)**	**(0.0008)**
SSP75+$_{NFR}$ (/10)	**0.0008**	**0.0003**	**0.0014***	**0.0016****	**0.0010**	**0.0008**
	(0.0005)	**(0.0005)**	**(0.0008)**	**(0.0008)**	**(0.0008)**	**(0.0008)**
FR: Self-reported health conditions	No	Yes	No	No	Yes	Yes
NFR: Self-reported health conditions	No	Yes	No	No	Yes	Yes
FR: Expectations regarding retirement income	No	No	Yes	No	Yes	Yes
NFR: Expectations regarding retirement income	No	No	Yes	No	Yes	Yes
FR: Expectations regarding retirement living standards	No	No	No	Yes	No	Yes
NFR: Expectations regarding retirement living standards	No	No	No	Yes	No	Yes
R^2	0.141	0.143	0.145	0.142	0.146	0.146
Observations	47,409	47,393	22,973	22,824	22,971	22,752

Notes: Standard errors are reported in parentheses. Each regression model includes demographic covariates, household economic conditions, S&P 500 index, Census division dummies, and year dummies. Significance levels are indicated by *, **, and *** for 10, 5, and 1 percent significance level, respectively.

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